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Radiological Health Data

VOLUME IV, NUMBER 2

FEBRUARY 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Surveillance of gross beta activity in air and precipitation permits quick and sensitive detection of fission product activity fluctuation in the environment. Although this information alone does not allow evaluation of biological effects due to fallout, it forms the basis of alerting systems and can be used as a rough index to determine when and where more extensive monitoring of radioactivity in food, milk, and water may be indicated.

October 1962 gross beta concentrations are presented in the following reports from the Canadian Radioactive Fallout Study Program, Radiation Surveillance Network, and 80th Meridian (West) Sampling Program. Because of differences in equipment and techniques the results of one network are not directly comparable with those of another. A study conducted by Lockhart and Patterson of the U.S. Naval Research Laboratory has determined intercalibration factors for comparing the results of the three networks (*1, 2*). Relative activity values determined for the three networks are: Canadian Air Monitoring Network, 1.00; Radiation Surveillance Network, 0.65; and NRL 80th Meridian Network, 1.12 (*2*). These factors are subject to the uncertainty of air volume measurements and may not hold for very young fission products.

Presented below for the first time in *Radiological Health Data* are the Mexican Radioactive Fallout Program air monitoring results. The data cover the 12-month period from October 1961 to September 1962.

REFERENCES

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850,* (November 13, 1962).

(*2*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems (March–June 1962), *Radiological Health Data, 3*:466–70, Public Health Service, Washington 25, D.C. (December 1962).

RADIATION SURVEILLANCE NETWORK
October 1962

Division of Radiological Health, Public Health Service

During October 1962, 72 sampling stations, distributed among the fifty States, Guam, and Puerto Rico, comprised the Radiation Surveillance Network (see figure 1). RSN sampling stations are manned predominantly by State Health Department personnel.

Air

Daily 24-hour air samples are collected by a high volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field measurements with a portable survey meter enable the station operator to estimate the amount of beta activity in airborne particulates at the station 5 hours after collection by com-

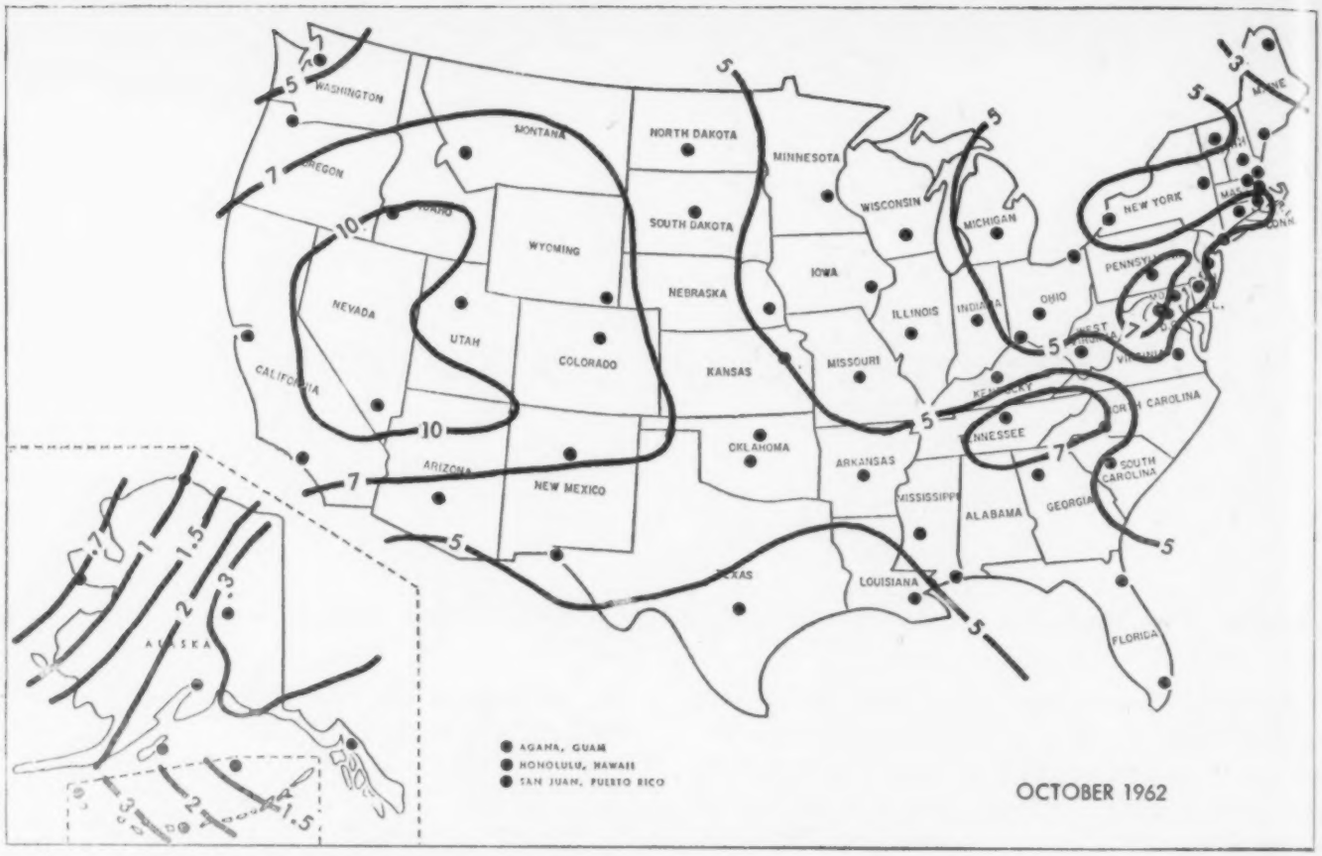

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$), OCTOBER 1962

parison with a known Sr^{90}-Y^{90} source. This 5-hour delay eliminates interference from naturally-occurring radon daughters. Each operator then reports his field estimate by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C., to provide a daily national report.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day interval, make possible the estimation of the age of fission products and extrapolation of the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2} = \text{constant}$).*

* In this expression, A is the activity and T is the time after fission product formation.

Although gross beta concentration is usually presented without reference to age, it is apparent that fission product activity is more adequately described when the age parameter is also given. Studies on determining a meaningful monthly average age of fission products are now in progress.

The average fission-product beta concentrations in surface air during October 1962, as determined by laboratory analysis and extrapolated to the time of collection, are tabulated in table 1 and presented by means of concentration contours in figure 1.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels having collection areas of 0.4 m^2. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated;

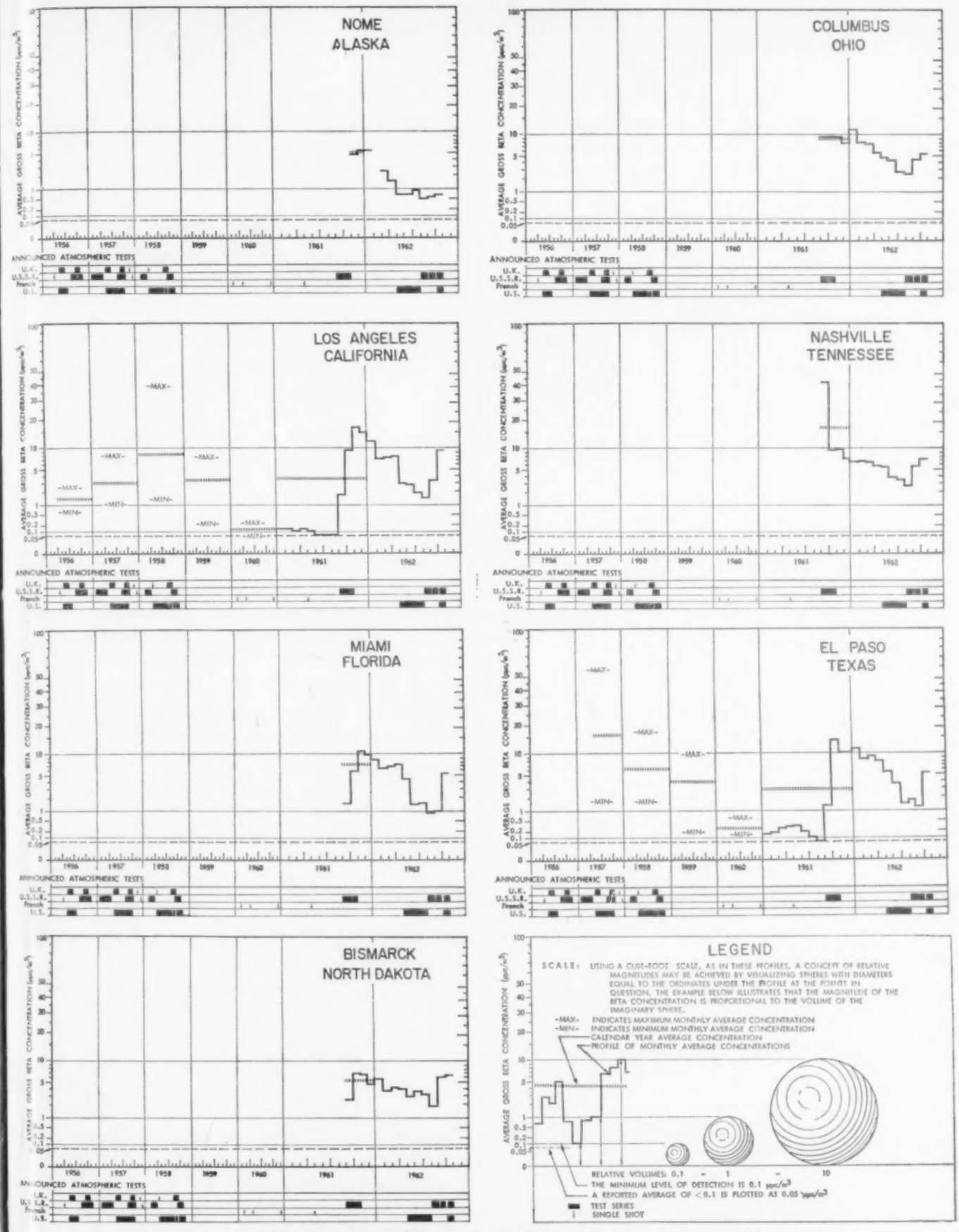

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–OCTOBER 1962

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, OCTOBER 1962

[Concentrations in $\mu\mu c/m^3$]

Station location		Number Samples	Maximum	Minimum	[a] Weighted Average
Alaska:	Adak	31	8.3	<0.10	2.2
	Anchorage	30	6.0	0.65	2.5
	Attu	31	24	<0.10	4.8
	Fairbanks	10	12	0.11	3.3
	Juneau	20	6.5	0.27	2.2
	Kodiak	31	7.2	0.71	2.6
	Nome	12	1.6	<0.10	0.70
	Point Barrow Isl	30	2.6	<0.10	1.0
	St. Paul Island	30	4.6	<0.10	1.4
Ariz:	Phoenix	31	47	3.0	12
Ark:	Little Rock	29	17	0.86	5.4
Calif:	Berkeley	31	22	0.80	6.8
	Los Angeles	21	32	2.3	9.7
Colo:	Denver	29	21	1.4	7.6
Conn:	Hartford	30	20	0.92	5.1
Del:	Dover	22	27	0.63	5.7
D.C:	Washington	31	21	0.37	4.7
Fla:	Jacksonville	31	24	0.31	6.0
	Miami	31	15	0.22	5.2
Ga:	Atlanta	31	29	0.57	5.4
Guam:	Agana	—	—	—	—
Hawaii:	Honolulu	31	16	0.36	3.1
Idaho:	Boise	31	36	0.78	10
Ill:	Springfield	31	12	0.87	4.5
Ind:	Indianapolis	30	17	1.9	4.9
Iowa:	Iowa City	30	12	0.38	3.2
Kans:	Topeka	29	18	0.26	5.0
Ky:	Frankfort	28	20	1.5	4.3
La:	New Orleans	31	13	0.13	4.5
Maine:	Augusta	31	7.7	0.96	3.2
	Presque Isle	31	6.5	0.18	2.3
Md:	Baltimore	23	23	0.81	5.4
	Rockville	20	12	2.0	7.4
Mass:	Lawrence	30	9.3	0.21	3.9
	Winchester	30	11	0.78	4.6
Mich:	Lansing	31	16	0.90	5.2
Minn:	Minneapolis	30	20	0.68	4.0
Miss:	Jackson	29	13	0.13	5.4
	Pascagoula	18	15	0.26	6.1
Mo:	Jefferson City	30	16	0.90	4.7
Mont:	Helena	31	25	1.7	9.1
Nebr:	Lincoln	16	4.3	0.30	1.8
Nev:	Las Vegas	28	72	3.3	14
N.H:	Concord	21	14	1.6	4.6
N.J:	Trenton	31	19	0.14	4.7
N. Mex:	Sante Fe	29	22	1.3	8.2
N.Y:	Albany	30	15	0.11	4.5
	Buffalo	28	9.9	0.12	4.6
	New York	15	22	0.17	4.8
N.C:	Gastonia	30	19	0.36	7.0
N. Dak:	Bismarck	31	25	0.42	6.7
Ohio:	Cincinnati	21	18	2.0	6.8
	Columbus	31	27	1.9	5.4
	Painesville	29	18	1.4	5.2
Okla:	Oklahoma City	31	18	0.24	5.2
	Ponca City	28	9.4	<0.10	2.5
Ore:	Portland	30	39	2.3	7.2
Pa:	Harrisburg	25	48	1.3	8.4
P.R:	San Juan	30	3.0	0.11	0.72
R.I:	Providence	31	12	0.13	5.0
S.C:	Columbia	31	12	0.18	4.4
S. Dak:	Pierre	31	15	0.54	5.8
Tenn:	Nashville	29	27	1.0	7.3
Tex:	Austin	30	17	0.12	4.7
	El Paso	30	15	0.45	5.2
Utah:	Salt Lake City	31	22	1.7	8.1
Vt:	Barre	31	17	0.54	5.5
Va:	Richmond	31	22	0.65	4.6
Wash:	Seattle	30	15	0.97	4.3
W. Va:	Charleston	31	21	1.5	4.7
Wis:	Madison	31	17	0.67	4.3
Wyo:	Cheyenne	31	29	1.5	8.2
Network average					5.2

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, OCTOBER 1962

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
Alaska	Adak	*	*
	Anchorage	1,300	1
	Attu	*	*
	Fairbanks	*	*
	Juneau	1,800	30
	Kodiak	*	*
	Nome	*	*
	Pt. Barrow Island	*	*
	St. Paul Island	*	*
Ariz.	Phoenix	*	*
Ark.	Little Rock	480	54
Calif.	Berkeley	400	120
	Los Angeles	27,000	16
Colo.	Denver	*	*
Conn.	Hartford	3,600	300
Del.	Dover	*	*
D.C.	Washington	920	38
Fla.	Jacksonville	640	20
	Miami	830	52
Ga.	Atlanta	900	7.8
Guam	Agana	*	*
Hawaii	Honolulu	*	*
Idaho	Boise	1,400	44
Ill.	Springfield	480	64
Ind.	Indianapolis	640	70
Iowa	Iowa City	1,100	98
Kans.	Topeka	2,700	9.5
Ky.	Frankfort	870	37
La.	New Orleans	1,900	69
Maine	Augusta	1,700	320
	Presque Isle	2,000	51
Md.	Baltimore	400	4
	Rockville	2,700	24
Mass.	Lawrence	7,000	200
	Winchester	1,200	70
Mich.	Lansing	4,700	210
Minn.	Minneapolis	1,100	49
Miss.	Jackson	450	17
	Pascagoula	400	10
Mo.	Jefferson City	1,800	150
Mont.	Helena	4,000	71
Nebr.	Lincoln	1,300	45
Nev.	Las Vegas	5,000	3
N.H.	Concord	*	*
N.J.	Trenton	1,100	8.9
N. Mex.	Santa Fe	760	11
N.Y.	Albany	1,200	48
	Buffalo	1,800	68
	New York	*	*
N.C.	Gastonia	440	18
N. Dak.	Bismarck	2,000	18
Ohio	Cincinnati	*	*
	Columbus	1,100	4.8
	Painesville	2,400	170
Okla.	Oklahoma City	600	15
	Ponca City	530	27
Ore.	Portland	2,200	120
Pa.	Harrisburg	600	50
P.R.	San Juan	400	110
R.I.	Providence	1,900	150
S.C.	Columbia	400	6.5
S. Dak.	Pierre	810	4.9
Tenn.	Nashville	590	29
Tex.	Austin	700	50
	El Paso	510	7.1
Utah	Salt Lake City	2,400	51
Vt.	Barre	860	100
Va.	Richmond	870	1.8
Wash.	Seattle	790	180
W. Va.	Charleston	1,300	42
Wis.	Madison	1,100	27
Wyo.	Cheyenne	920	10

* Indicates no evaporated sample received.

if less than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. October 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and millimicrocuries per square meter ($m\mu c/m^2$), are shown in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for 7 stations, updated through October 1962, are shown in figure 2.

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
October 1962

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division, Department of National Health and Welfare, Dominion of Canada, conducts air and precipitation sampling programs. The 24 air and precipitation stations are located at airports (see figure 3), and the equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport.

More detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's annual reports for 1959 and 1960 (*1,2*).

Air

About 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. Filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. A 2-inch-diameter disk is removed from each filter and counted with a thin end-window Geiger flow counter system, calibrated with a Sr^{90}-Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Air data for October 1962 are presented in table 3.

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. October 1962 precipitation data, including some radiochemical analyses, are presented in table 4. (see p. 68).

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

REFERENCES

(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW (RP–3)*, (May 1960).
(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW (RP–3)*, (December 1961).

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RFSP, OCTOBER 1962

[Average concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Calgary	31	49.3	2.5	18.0
Chatham	31	12.5	0.1	4.8
Coral Harbor	2*	20.0	0.1	3.2
Edmonton	31	76.5	0.5	13.2
Ft. Churchill	31	15.5	0.5	3.1
Ft. William	31	20.6	1.7	7.3
Fredericton	31	13.6	1.2	5.0
Goose Bay	30	12.9	0.0	4.8
Inuvik	31	9.6	0.0	2.7
Kapuskasing	29	13.5	1.4	5.8
Montreal	30	36.0	1.5	8.1
Moosonee	28	11.7	1.7	5.6
Ottawa	30	23.0	1.0	8.0
Regina	31	112.0	1.7	14.8
Resolute	8	1.6	0.6	1.2
Saskatoon	31	70.0	1.8	15.1
Shearwater	31	47.0	0.7	6.6
Torbay	30	16.6	0.0	4.6
Toronto	31	20.0	0.1	8.4
Vancouver	31	25.8	1.5	8.8
Whitehorse	31	13.3	0.8	4.4
Windsor	29	27.5	2.8	10.3
Winnipeg	29	52.0	1.2	12.9
Yellowknife	31	15.5	0.2	4.4
Network Average				7.5

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, OCTOBER 1962

Station	Total beta activity		Deposition of specific radionuclides for selected samples (mμc/m²)				
	μμc/liter	mμc/m²	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba[illegible]
Calgary	9,804	94.6	6.31	0.30	14.4	0.45	7.0
Chatham	2,234	286.0					
Coral Harbour	1,894	46.2					
Edmonton	6,208	69.4					
Fredericton	3,025	245.0					
Ft. Churchill	1,218	46.0					
Ft. William	6,980	88.6					
Goose Bay	838	63.1					
Inuvik	3,178	63.8					
Kapuskasing	698	26.7					
Montreal	1,984	231.2	18.8	0.88	33.5	1.35	13.4
Moosonee	1,968	88.0					
Ottawa	2,686	308.3					
Regina	3,443	125.0					
Resolute	9,223	72.6					
Saskatoon	9,701	69.0					
Shearwater	532	77.2	18.3	0.69	11.0	1.18	24.1
Torbay	664	108.4					
Toronto	1,631	113.0					
Vancouver	1,455	173.6	15.8	0.71	21.6	1.30	21.6
Whitehorse	1,874	49.0					
Windsor	2,099	87.4					
Winnipeg	4,677	86.7	5.65	0.30	15.8	0.53	10.3
Yellowknife	2,025	31.9					
Average	3,335	110.4					

[1] All values corrected for decay back to end of collection month.
[2] Values for strontium–90, cesium–137, and Zirconium–95 do not include the activities of their daughter isotopes, yttrium–90, barium–137, and niobium–95.

MEXICAN RADIOACTIVE FALLOUT PROGRAM
October 1961–September 1962

National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the "Comisión Nacional de Energía Nuclear" (CNEN), through its Radiological Protection Program (RPP) in 1961, to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to eleven stations, nine of which were in operation by the end of September 1962 (see figure 4 and table 5).

Seven of the nine sampling stations are located at airports and operated by airline personnel. The remaining two stations are located at Mexico City and Veracruz and are operated, respectively, by staff members of RPP and the "Centro de Previsión del Golfo de México."

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 5.—GEOGRAPHICAL SITUATION OF SAMPLING STATIONS

Station	Latitude	Elevation (meters above sea level)
México, D. F.	19°20′N	2,268
San Luis Potosí	22°09′N	1,877
Torreón	25°32′N	1,140
Matamoros	25°52′N	12
Veracruz	19°12′N	14
Mérida	20°59′N	9
Acapulco	16°50′N	2
Guadalajara	20°40′N	1,517
La Paz	24°09′N	10
Tijuana	32°30′N	—
Ciudad Juárez	28°38′N	1,660

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day through a 6″ x 8″ high-efficiency glass fiber filter, using high volume samplers. After each 24-hour period the filter is removed and air-mailed to the "Laboratorio de Desechos Radiactivos," CNEN, in Mexico City for assay of gross beta activity. After collection, a minimum of 3 or 4 days is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission product beta concentrations in surface air from October 1961 to September 1962 are presented in table 6.

TABLE 6.—GROSS BETA ACTIVITY OF PARTICLES IN AIR, OCTOBER 1961—SEPTEMBER 1962

[Concentrations in $\mu\mu c/m^3$]

Month	Station	Number of samples	Maximum	Minimum	Average
1961					
October	México	14	5.88	0.10	1.52
	San Luis Potosí	7	10.71	0.51	3.86
November	México	16	3.83	0.10	1.42
	San Luis Potosí	6	13.42	0.46	4.02
December	México	15	11.53	1.43	5.84
	San Luis Potosí	6	3.83	1.19	2.58
1962					
January	México	13	8.23	2.58	6.04
	San Luis Potosí	11	29.64	0.61	9.59
February	México	9	7.54	2.55	4.41
	San Luis Potosí	10	17.10	2.93	7.43
March	México	10	3.43	0.64	1.94
	San Luis Potosí	9	13.64	0.92	7.82
April	México	5	3.47	0.43	2.00
	San Luis Potosí	9	13.64	0.92	7.82
	Torreón	12	13.40	4.47	8.63
	Veracruz	5	15.08	4.36	8.54
	La Paz	3	7.41	1.95	4.52
May	México	6	9.81	4.90	7.07
	San Luis Potosí	12	12.26	4.63	7.16
	Torreón	12	11.25	3.51	6.45
	Veracruz	3	9.88	4.40	7.62
	La Paz	9	5.95	2.14	3.62
	Acapulco	4	6.37	2.41	4.13
	Tijuana	12	8.06	0.72	4.17
June	San Luis Potosí	11	6.11	0.39	2.58
	Torreón	10	4.56	0.51	2.62
	Veracruz	10	2.25	0.84	1.15
	La Paz	12	5.61	1.31	3.32
	Acapulco	4	2.24	0.75	1.40
	Ciudad Juárez	4	17.66	2.39	8.14
July	México	10	4.60	0.90	2.42
	San Luis Potosí	7	4.90	0.50	1.91
	Torreón	7	2.30	0.50	1.59
	Veracruz	6	1.60	0.50	0.95
	La Paz	7	63.50	1.10	11.26
	Acapulco	4	1.00	0.20	0.62
	Ciudad Juárez	9	4.90	1.00	1.97
August	México	20	10.10	0.20	2.53
	San Luis Potosí				
	Torreón	10	30.40	0.30	6.63
	Veracruz	9	1.00	0.20	0.70
	La Paz	4	2.60	0.80	1.52
	Acapulco				
	Ciudad Juárez	13	18.40	1.10	5.14
	Tijuana	5	3.00	0.90	1.76
	Guadalajara	16	1.50	0.20	0.72
September	México	9	0.60	0.20	0.24
	San Luis Potosí	10	0.80	0.10	0.43
	Torreón	5	1.50	0.40	0.78
	Veracruz	7	0.80	0.20	0.51
	La Paz	4	14.70	0.40	4.52
	Acapulco	3	0.30	0.20	0.25
	Ciudad Juárez	7	6.50	0.70	3.24
	Tijuana	5	8.10	3.80	6.20
	Guadalajara	8	1.00	0.10	0.63

*Dash indicates no data received.

THE 80th MERIDIAN (WEST) SAMPLING PROGRAM
October 1962

U.S. Naval Research Laboratory

Radioactivity measurements of surface air samples collected at various sites (see figure 5) near the 80th Meridian (West) have been made since 1956 by the U.S. Naval Research Laboratory (NRL),* with the cooperation of interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile, which collect the samples and forward them to NRL for analysis. Partial financial support of this program is provided by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

The sampling procedure involves drawing air continuously for a 7-day period at a rate of approximately 1200 cubic meters per day through an 8-inch diameter, high-efficiency filter, using a positive-displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. Data in table 7 are not extrapolated to time of collection.

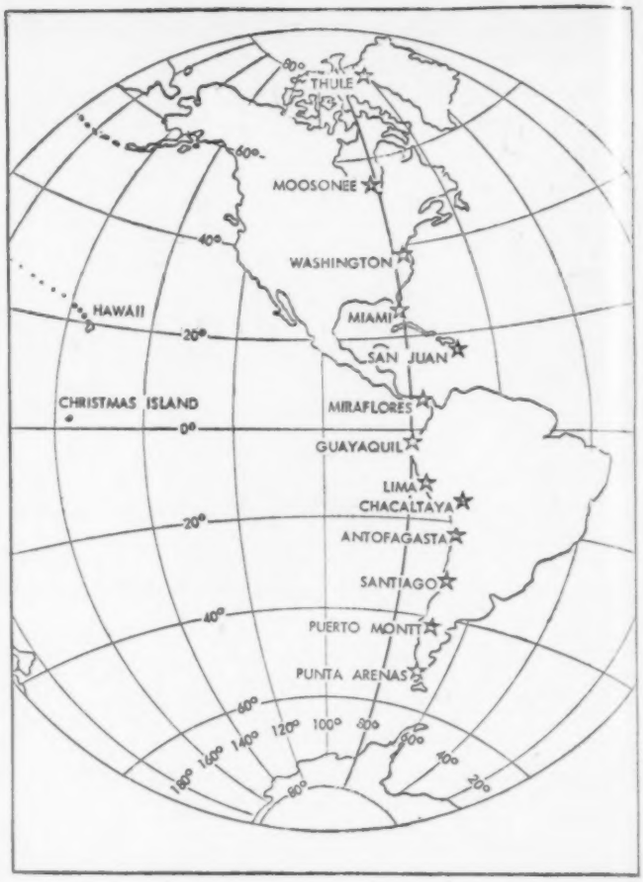

FIGURE 5.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

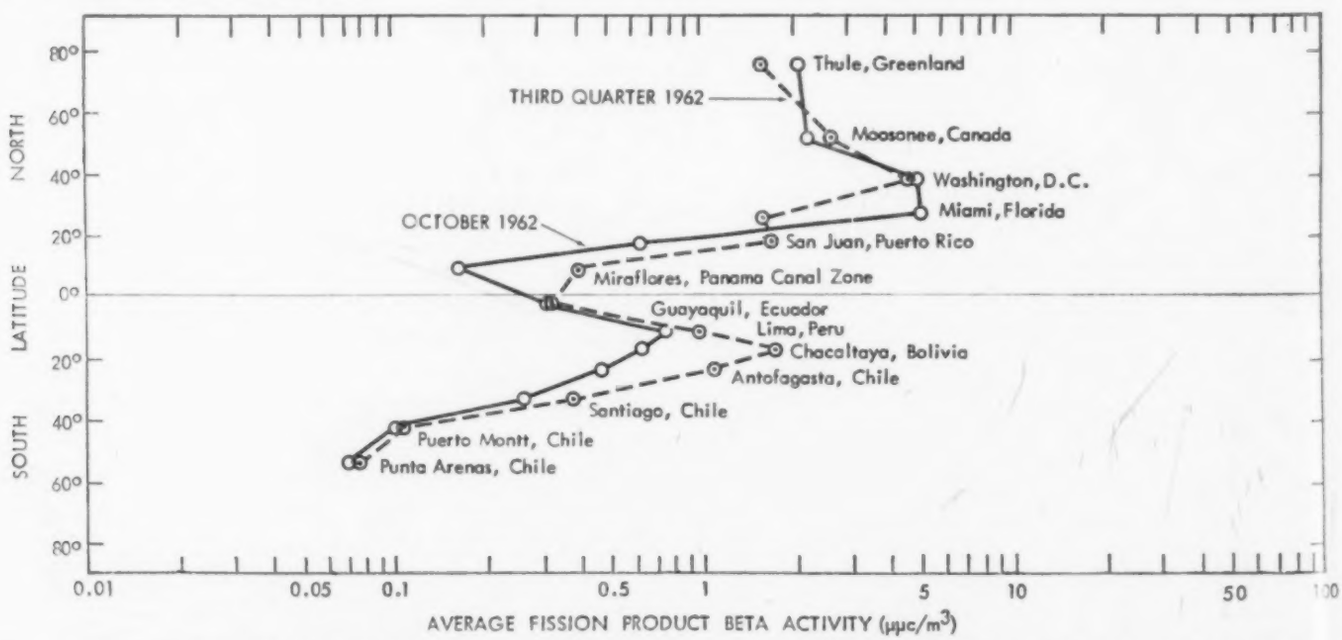

FIGURE 6.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENT OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST) OCTOBER 1962

** Editor's note: Effective January 1, 1963, administration of the 80th Meridian (West) Sampling Program was turned over to the Health and Safety Laboratory, Division of Biology and Medicine, AEC, by the U.S. Naval Research Laboratory.*

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN (WEST), OCTOBER 1962[a]

Sampling period October	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, P. R.	Mauna Loa, Hawaii[b]	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1	0.139	0.145	0.398	0.868	0.630	0.828	1.22	—	0.077	0.868	0.860	2.19	1.87	2.06
2 3 4 5 6 7 8	0.054	0.099	0.280	0.353	0.949	0.792	0.054	0.077	0.500	[c]—	1.48	3.71	3.73	2.06
9 10 11 12 13 14 15	. —	0.141	0.282	0.630	0.706	0.742	0.108	0.271	0.500	1.90	4.44	3.98	3.38	2.43
16 17 18 19 20 21 22	0.084	0.076	0.258	0.554	0.446	0.464	0.576	0.138	0.486	1.19	6.48	7.02	1.25	1.56
23 24 25 26 27 28 29	0.065	0.098	—	0.310	0.459	0.999	0.175	0.182	0.842	2.74	8.37	5.90	1.15	2.45
30 31	0.069	—	0.290	0.711	0.662	—	0.102	0.144	1.42	2.07	6.62	3.31	1.86	2.12
Weighted average	0.071	0.105	0.280	0.490	0.639	0.752	0.325	0.166	0.644	1.91	5.13	4.95	2.33	2.12

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period (normally 7 days). Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period or that portion of the sampling period occurring in October 1962.
[b] Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters) and about equally distant north and south of the quator.
[c] Dash indicates samples were not received.

Airborne Fission Products Along the 80th Meridian (West) During 1961

L. B. Lockhart, Jr., R. L. Patterson, Jr.
A. W. Saunders, Jr., and R. W. Black[1]

The cooperative 80th Meridian (West) Air Sampling Program, conducted since its inception in 1956 under the direction of the U.S. Naval Research Laboratory,[2] was designed to provide a means of studying the effect of latitude on the distribution of fission products in the atmosphere, to obtain information on the mechanism and rate of mixing of fission debris in a north-south direction and particularly across the equator, and to serve as a reference line to which the various independent measurements of fission product concentrations could be related. An important and time-consuming phase of this work involved the radiochemical analysis of the collected samples whose gross beta measurements are regularly reported in this journal.

Experimental Procedure

The procedure employed at each site involved the collection of airborne particulate matter by drawing ground-level air through highly efficient cellulose-asbestos filters 8 inches in diameter at the rate of about 1200 cubic meters

[1] Dr. Lockhart is Head of the Physical Chemistry Branch, and Mr. Patterson is Head and Messrs. Saunders and Black are staff members of the Radiochemistry Section, Physical Chemistry Branch, U.S. Naval Research Laboratory, Washington, D.C.
[2] Partial financial support of this program has been provided by the Fallout Studies Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission.

TABLE 1.—RADIOCHEMICAL ANALYSES OF BIMONTHLY COMPOSITE AIR-FILTER COLLECTIONS, 80TH MERIDIAN (WEST) SAMPLING PROGRAM, 1961

(Activity in $\mu\mu c/m^3$)[a]

Station	Sampling period		Gross β	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Ce^{137}	Pb^{210}
	1961	Days sampled[b]									
Thule, Greenland (elevation 259 meters)	Jan–Feb	59	0.054	c*	*	*	0.0067	0.0069	0.00220	0.00390	0.0102
	Mar–Apr	59	0.090	*	d—	—	—	—	0.00438	0.0074	0.0114
	May–Jun	63	0.072	*	*	*	0.0096	0.0100	0.00325	0.0064	0.0063
	Jul–Aug	59	0.032	*	*	*	0.0037	0.0048	0.00158	0.00277	0.00329
	Sep–Oct	63	1.38	0.303	0.114	0.160	0.048	0.0118	0.00140	0.00204	0.00359
	Nov–Dec	58	5.58	1.12	0.562	0.886	0.344	—	0.0092	0.0119	0.0092
Moosonee, Canada (elevation 10 meters)	Jan	25	0.050	*	*	*	0.00418	0.00353	0.00132	0.00209	0.0134
	Mar	32	0.10	*	*	*	0.0094	0.0087	0.00305	0.0062	0.0239
	May–Jun	56	0.090	*	*	*	0.0127	0.0134	0.0047	0.0074	0.0046
	Jul–Aug	63	0.036	*	*	*	0.0064	0.0075	0.00264	0.0050	0.0067
	Sep–Oct	59	3.65	0.788	0.261	0.395	0.099	0.0245	0.00285	0.0056	0.0070
	Nov–Dec	59	3.74	0.598	0.317	0.495	0.192	—	0.0046	0.0093	0.0159
Washington, D.C. (elevation 82 meters)	Jan–Feb	59	0.063	*	*	*	0.0067	0.0054	0.00198	0.00377	0.0245
	Mar–Apr	60	0.094	*	*	*	0.0108	0.0111	0.00332	0.0070	0.0156
	May–Jun	63	0.14	*	*	*	0.0176	0.0201	0.0060	0.0118	0.0144
	Jul–Aug	58	0.072	*	*	*	0.0070	0.0063	0.00238	0.0050	0.0098
	Sep–Oct	63	3.88	1.089	0.437	0.526	0.125	0.0321	0.00364	0.0069	0.0243
	Nov–Dec	56	4.66	0.742	0.590	0.819	0.297	—	0.0067	0.0127	0.0081
Miami, Florida (elevation 4 meters)	Jan–Feb	61	0.086	*	*	*	0.0091	0.0078	0.00248	0.00375	0.0086
	Mar–Apr	60	0.16	*	*	*	0.0195	0.0195	0.0058	0.0095	0.0128
	May–Jun	62	0.10	*	*	*	0.0141	0.0141	0.00434	0.0082	0.0102
	Jul–Aug	51	0.036	*	*	*	0.00430	0.0057	0.00159	0.00242	0.0065
	Sep–Oct	63	2.25	0.761	0.307	0.353	0.0801	0.0178	0.00304	0.00342	0.00442
	Nov–Dec	56	6.73	1.90	0.819	1.33	0.459	—	0.0124	0.0094	0.00378
Mauna Loa, Hawaii (elevation 3394 meters)	Jan–Feb	59	0.050	*	*	*	0.0055	0.0050	0.00173	0.00304	0.0068
	Mar–Apr	60	0.11	*	*	*	0.0184	0.0142	0.00444	0.0083	0.0084
	May–Jun	63	0.12	*	*	*	0.0143	0.0128	0.0050	0.0090	0.0110
	Jul–Aug	59	0.058	*	*	*	0.0075	0.0085	0.00270	0.0053	0.0084
	Sep–Oct	53	0.60	0.114	0.050	0.054	0.0158	0.0057	0.00145	0.00274	0.0050
	Nov–Dec	56	4.95	0.918	0.630	0.909	0.301	—	0.0076	0.0130	0.00260
Miraflores, Panama Canal Zone (elevation 10 meters	Jan–Feb	59	0.16	0.0090	0.0046	0.0046	0.0055	0.00429	0.00136	0.00238	0.00339
	Mar–Apr	60	0.063	e 1.0055	*	*	0.0050	0.0057	0.00156	0.00249	0.0060
	May–Jun	63	0.050	*	*	*	0.00389	0.00411	0.00125	0.00228	0.0086
	Jul–Aug	59	0.014	*	*	*	0.00084	0.00100	0.00031	0.00049	0.00343
	Sep–Oct	63	0.032	e 0.0048	e 0.0022	e 0.0036	0.00074	0.00032	0.00018	0.00042	0.00190
	Nov–Dec	55	1.23	0.217	0.115	0.190	0.057	0.0220	0.00158	0.00173	0.00140
Guayaquil, Ecuador (elevation 7 meters)	Jan–Feb	53	0.022	f 0.0027	f 0.0001	*	0.00127	0.00220	0.00038	0.00086	0.0101
	Mar–Apr	59	0.022	*	*	*	0.00106	0.00103	0.00036	0.00091	0.0121
	May–Jun	33	0.018	*	*	*	0.00112	0.00104	0.00039	0.00072	0.0081
	Jul–Aug	56	0.009	*	*	*	0.00045	0.00057	0.00021	0.00043	0.0070
	Sep–Oct	63	0.014	f 0.0001	*	*	0.00090	0.00121	0.00045	0.00094	0.0069
	Nov–Dec	62	0.058	0.0144	0.0104	0.0130	0.0064	0.00321	0.00108	0.00238	0.0107
Lima, Peru (elevation 30 meters)	Jan–Feb	51	0.018	*	*	*	0.00189	0.00151	0.00070	0.00129	0.00248
	Mar–Apr	60	0.014	*	*	*	0.00108	0.00089	0.00044	0.00087	0.00080
	May–Jun	63	0.027	*	*	*	0.00233	0.00202	0.00094	0.00093	0.00371
	Jul–Aug	52	0.027	*	*	*	0.00256	0.00248	0.00112	0.00170	0.00317
	Sep–Oct	61	0.032	*	*	*	0.0049	0.0054	0.00234	0.00832	0.00285
	Nov–Dec	64	0.027	e 0.0030	e 0.0027	e 0.0038	0.00301	0.00241	0.00112	0.00199	0.00212
Chacaltaya, Bolivia (elevation 5220 meters)	Jan–Feb	51	0.022	*	*	*	0.00131	0.00109	0.00044	0.00102	0.0084
	Mar–Apr	54	0.027	*	*	*	0.00171	0.00169	0.00068	0.00148	0.0090
	May–Jun	51	0.027	*	*	*	0.00164	0.00153	0.00068	0.00152	0.0116
	Jul–Aug	63	0.050	*	*	*	0.0051	0.0058	0.00216	0.00408	0.0171
	Sep–Oct	62	0.045	f 0.0019	*	f 0.0009	0.00343	0.00393	0.00168	0.00310	0.0132
	Nov–Dec	63	0.068	e 0.0072	e 0.0053	e 0.0068	0.00456	0.00293	0.00124	0.00232	0.00940
Antofagasta, Chile (elevation 519 meters)	Jan–Feb	43	0.054	*	*	*	0.0063	0.0053	0.00228	0.00344	0.0061
	Mar–Apr	60	0.036	*	*	*	0.00428	0.00410	0.00157	0.00335	0.0155
	May–Jun	60	0.036	*	*	*	0.00359	0.00356	0.00140	0.00275	0.0174
	Jul–Aug	52	0.032	*	*	*	0.0046	0.0050	0.00186	0.00333	0.00445
	Sep–Oct	63	0.036	f 0.0037	*	*	0.0059	0.0063	0.00254	0.00513	0.00226
	Nov–Dec	63	0.072	e 0.0057	e 0.0040	e 0.0059	0.0071	0.0071	0.00266	0.00481	0.00268
Santiago, Chile (elevation 520 meters)	Jan	25	0.058	*	*	*	0.0089	0.0080	0.00319	0.0065	0.0058
	Mar–Apr [g]										
	May	31	0.036	*	*	*	0.00306	0.00247	0.00125	0.00199	0.0125
	Jul–Aug [h]										
	Sep–Oct	63	0.032	*	*	f 0.0010	0.00437	0.0063	0.00188	0.00409	0.00366
	Nov–Dec	63	0.045	f 0.0004	f 0.0008	f 0.0007	0.00409	0.0055	0.00222	0.00452	0.0056
Puerto Montt, Chile (elevation 5 meters)	Jan–Feb [g]										
	Mar–Apr [h]										
	May–Jun [h]										
	Jul–Aug	54	0.018	*	*	*	0.00209	0.00216	0.00097	0.00140	0.00266
	Sep–Oct	63	0.018	*	*	*	0.00227	0.00276	0.00117	0.00132	0.00123
	Nov–Dec	63	0.018	*	f 0.0007	*	0.00288	0.00353	0.00157	0.00239	0.00179
Punta Arenas, Chile (elevation 3 meters)	Jan–Feb	47	0.018	*	*	*	0.00220	0.00193	0.00083	0.00167	0.00072
	Mar–Apr	60	0.014	*	*	*	0.00182	0.00191	0.00080	0.00156	0.00116
	May–Jun	44	0.014	*	*	*	0.00121	0.00106	0.00049	0.00094	0.00071
	Aug–Sep [i]	55	0.014	*	*	*	0.00130	0.00151	0.00063	0.00119	0.00079
	Oct	35	0.009	*	*	*	0.00098	0.00150	0.00060	0.00118	0.00066
	Nov–Dec	56	0.009	f 0.0004	f 0.0004	*	0.00084	0.00112	0.00050	0.00101	0.00057

[a] Counting error <2 percent (σ) unless otherwise indicated. [b] Irregularities in numbers result from varying sampling schedules; initially 3 samples per week per station, later one 7-day collection per week. [c] * indicates activity too low for measurement. [d] — indicates no analytical results reported. [e] Counting error in range of 2–10 percent (σ). [f] Indicates counting error >10 percent (σ). [g] No samples received. [h] Insufficient samples received. [i] Error made in grouping samples for analysis.

TABLE 2.—SELECTED RADIONUCLIDE ACTIVITY RATIOS, 80TH MERIDIAN SAMPLING PROGRAM, 1961

Station	Sampling period		Ce^{141}/Ce^{144}	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}	Pb^{210}/Sr^{90}	$\frac{Pb^{210}}{\text{Gross } \beta}$	Sr^{89}/Sr^{90}
	1961	Days sampled							
Thule, Greenland	Jan–Feb	59	0.0	0.97	3.05	1.77	4.6	0.19	0.0
	Mar–Apr	59	—	—	—	1.69	2.8	0.14	0.0
	May–Jun	63	0.0	0.97	2.95	1.97	2.1	0.09	0.0
	Jul–Aug	59	0.0	0.77	2.35	1.76	2.1	0.10	0.0
	Sep–Oct	63	6.35	4.05	34.0	1.45	2.6	0.0026	81.4
	Nov–Dec	58	3.26		37.3	1.29	1.0	0.0017	61.0
Moosonee, Canada	Jan	25	0.0	1.19	3.16	1.58	14.6	0.39	0.0
	Mar	32	0.0	1.08	3.07	2.02	7.2	0.21	0.0
	May–Jun	56	0.0	0.95	2.70	1.56	0.76	0.04	0.0
	Jul–Aug	63	0.0	0.85	2.42	1.88	2.5	0.18	0.0
	Sep–Oct	59	7.99	4.03	34.6	1.97	2.4	0.0019	91.5
	Nov–Dec	59	3.11		41.4	2.00	3.4	0.0043	68.3
Washington, D.C.	Jan–Feb	59	0.0	1.23	3.36	1.90	12.3	0.39	0.0
	Mar–Apr	60	0.0	0.97	3.25	2.11	4.7	0.17	0.0
	May–Jun	63	0.0	0.87	2.93	1.98	2.4	0.10	0.0
	Jul–Aug	58	0.0	1.12	2.94	2.09	4.1	0.14	0.0
	Sep–Oct	63	8.74	3.88	34.2	1.90	6.7	0.0062	120.
	Nov–Dec	56	2.50		44.3	1.90	1.2	0.0017	87.9
Miami, Florida	Jan–Feb	61	0.0	1.17	3.69	1.52	3.5	0.10	0.0
	Mar–Apr	60	0.0	1.00	3.38	1.65	2.2	0.08	0.0
	May–Jun	62	0.0	1.00	3.25	1.89	2.4	0.10	0.0
	Jul–Aug	51	0.0	0.75	2.70	1.52	4.1	0.18	0.0
	Sep–Oct	63	9.49	4.51	26.4	1.13	1.5	0.0020	101.
	Nov–Dec	56	4.14		37.0	0.76	3.0	0.0006	65.0
Mauna Loa, Hawaii	Jan–Feb	59	0.0	1.10	3.18	1.76	3.9	0.14	0.0
	Mar–Apr	60	0.0	1.30	4.15	1.87	1.9	0.074	0.0
	May–Jun	63	0.0	1.12	2.89	1.82	2.2	0.090	0.0
	Jul–Aug	59	0.0	0.88	2.77	1.95	3.1	0.14	0.0
	Sep–Oct	53	7.23	2.78	10.8	1.89	3.5	0.0084	34.4
	Nov–Dec	56	3.05		39.6	1.70	0.34	0.0005	84.3
Miraflores, Panama Canal Zone	Jan–Feb	59	1.63	1.28	4.07	1.75	2.5	0.021	3.4
	Mar–Apr	60	1.1	0.88	3.21	1.60	3.8	0.095	0.0
	May–Jun	63	0.0	0.95	3.11	1.82	6.8	0.17	0.0
	Jul–Aug	59	0.0	0.83	2.74	1.60	11.2	0.25	0.0
	Sep–Oct	63	6.4	2.36	4.02	2.27	10.3	0.06	12.0
	Nov–Dec	55	3.80	2.59	36.1	1.09	0.89	0.0011	72.7
Guayaquil, Ecuador	Jan–Feb	53	[a] 2.0	0.58	3.33	2.25	26.	0.45	[a] 0.2
	Mar–Apr	59	0.0	1.03	2.90	2.49	33.	0.54	0.0
	May–Jun	33	0.0	1.09	2.91	1.85	21.	0.45	0.0
	Jul–Aug	56	0.0	0.79	2.11	2.02	33.	0.78	0.0
	Sep–Oct	63	[a] 0.2	0.74	1.97	2.06	15.2	0.51	0.0
	Nov–Dec	62	2.25	1.99	5.94	2.22	9.9	0.18	9.7
Lima, Peru	Jan–Feb	51	0.0	1.25	2.69	1.83	3.5	0.14	0.0
	Mar–Apr	60	0.0	1.21	2.47	1.99	1.8	0.06	0.0
	May–Jun	63	0.0	1.15	2.49	0.99	4.0	0.14	0.0
	Jul–Aug	52	0.0	1.03	2.29	1.52	2.8	0.12	0.0
	Sep–Oct	61	0.0	0.96	2.21	1.63	1.2	0.09	0.0
	Nov–Dec	64	1.00	1.25	2.70	1.78	1.9	0.08	2.4
Chacaltaya, Bolivia	Jan–Feb	51	0.0	1.21	3.01	2.34	19.2	0.37	0.0
	Mar–Apr	54	0.0	1.01	2.54	2.19	13.4	0.34	0.0
	May–Jun	51	0.0	1.07	2.39	2.22	17.0	0.43	0.0
	Jul–Aug	63	0.0	0.89	2.37	1.89	7.9	0.35	0.0
	Sep–Oct	62	[a] 0.6	0.87	2.04	1.84	7.8	0.29	0.0
	Nov–Dec	63	1.6	1.56	3.67	1.87	7.6	0.14	4.2
Antofagasta, Chile	Jan–Feb	43	0.0	1.21	2.78	1.51	2.7	0.11	0.0
	Mar–Apr	60	0.0	1.04	2.72	2.13	9.9	0.43	0.0
	May–Jun	60	0.0	1.01	2.57	1.97	12.5	0.48	0.0
	Jul–Aug	52	0.0	0.93	2.47	1.79	2.4	0.14	0.0
	Sep–Oct	63	[a] 0.6	0.97	2.32	2.02	0.89	0.06	0.0
	Nov–Dec	63	0.8	1.00	2.66	1.81	1.01	0.037	1.5
Santiago, Chile	Jan	25	0.0	1.11	2.78	2.03	1.8	0.10	0.0
	Mar–Apr [b]								
	May	31	0.0	1.24	2.44	1.59	10.0	0.35	0.0
	Jul–Aug [c]								
	Sep–Oct	63	0.0	0.69	2.33	2.17	1.9	0.12	0.0
	Nov–Dec	63	[a] 0.11	0.74	1.84	2.03	2.5	0.13	[a] 0.4
Puerto Montt, Chile	Jan–Feb [b]								
	Mar–Apr [c]								
	May–Jun [c]								
	Jul–Aug	54	0.0	0.98	2.16	1.45	2.7	0.15	0.0
	Sep–Oct	63	0.0	0.82	1.93	1.13	1.05	0.07	0.0
	Nov–Dec	63	0.0	0.82	1.83	1.58	0.50	0.04	[a] 0.4
Punta Arenas, Chile	Jan–Feb	47	0.0	1.14	2.64	2.00	0.87	0.04	0.0
	Mar–Apr	60	0.0	0.96	2.29	1.95	0.20	0.012	0.0
	May–Jun	44	0.0	1.14	2.48	1.94	1.45	0.05	0.0
	Aug–Sep	55	0.0	0.87	2.07	1.89	1.25	0.06	0.0
	Oct	35	0.0	0.65	1.62	1.96	1.09	0.07	0.0
	Nov–Dec	56	[a] 0.5	0.75	1.68	2.02	1.14	0.06	[a] 0.8

[a] Value uncertain—error exceeds 10 percent.
[b] No samples received.
[c] Insufficient samples received.

per day. Sampling was conducted on a weekly basis during most of 1961 with filters changed every Monday after 7 days exposure. These filters were returned to NRL by air for assay for gross beta activity and subsequently for radiochemical analysis.

Radiochemical analyses were performed bimonthly on samples from each site (except San Juan) for the following radioisotopes: Sr^{89}, Sr^{90}, Y^{91}, Cs^{137}, Ce^{141}, Ce^{144}, Pm^{147} and Pb^{210}. After dissolution of the sample and addition of carrier elements, classical chemical separation schemes were employed followed by elaborate radiochemical purification procedures (*1*). Counting of beta activity was done with halogen-filled or flow-type Geiger counters which had been standardized against calibrated samples of the same size and weight having known disintegration rates of radioisotopes of various beta (maximum) energies. Decay and absorption measurements were made as occasion demanded.

The results of the radiochemical analyses are presented in table 1 in units of micromicrocuries per cubic meter of standard air. Some of the activity ratios of current interest appear in table 2 (*2*). All radioactivity results except for the gross beta measurements have been corrected for decay to the midpoint of the collection period.

Gross Fission Products in the Air

The gross beta activity of the individual samples and the monthly profiles of radioactivity vs. latitude along the 80th Meridian have been reported in previous issues of *Radiological Health Data*. Some of these data have been replotted in figure 1 to show the progressive changes that have occurred in the gross fission product concentrations in the air at Washington, D.C., Miami, Fla., and Antofagasta, Chile during the period 1959–1961. The increases in activity during the spring season are evident at the two Northern Hemisphere sites but are less obvious at Antofagasta. The 1961 U.S.S.R. tests caused a hundred-fold increase in radioactivity at Washington and Miami, with activity levels at these two sites approximating those observed following the fall 1958 series of high yield nuclear tests in the U.S.S.R.

The only effect of the French nuclear testing program at the above sites was an increase in

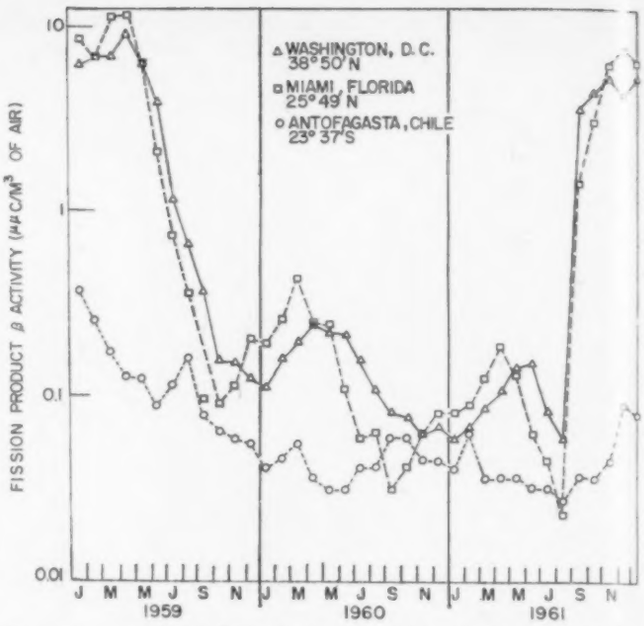
10
1
0.1
0.01
FISSION PRODUCT β ACTIVITY (μμC/M³ OF AIR)
△ WASHINGTON, D.C. 38° 50' N
□ MIAMI, FLORIDA 25° 49' N
○ ANTOFAGASTA, CHILE 23° 37' S
J M M J S N J M M J S N J M M J S N
1959
1960
1961

FIGURE 1.—PROGRESSIVE CHANGES IN THE CONCENTRATION OF GROSS FISSION PRODUCTS IN THE AIR AT WASHINGTON, MIAMI AND ANTOFAGASTA, 1959–1961

activity at Miami in March 1960 following the first test in the Sahara Desert on February 13, 1960. None of the other tests there produced any identifiable change in the gross beta activity at these three sites, although activity from the test of December 27, 1960 was detected for a short time at Miraflores, Panama Canal Zone and San Juan, Puerto Rico in January 1961.

Strontium–90 in the Air at Ground Level

The strontium–90 concentrations in the air of the Northern Hemisphere were generally lower in 1961 (prior to the 1961 U.S.S.R. tests) than in the previous year but the rate of decrease during the period 1960 to 1961 was significantly lower than during 1959 to 1960. The changes in the strontium–90 concentrations that have occurred at four sites in the North Temperate Zone during the period January 1959 through February 1962 are shown in figure 2. The spring maxima in stratospheric deposition are evident in each of the years 1959, 1960 and 1961 with relatively little difference indicated between the latter two years. The great increase in the strontium–90 concentration following resumption of nuclear testing by the U.S.S.R. in September 1961 is

apparent with strontium–90 levels approaching those of the 1958–1959 period. The delay in appearance of the highest concentrations of strontium–90 in the ground level air until early 1962 indicates that the major part of this

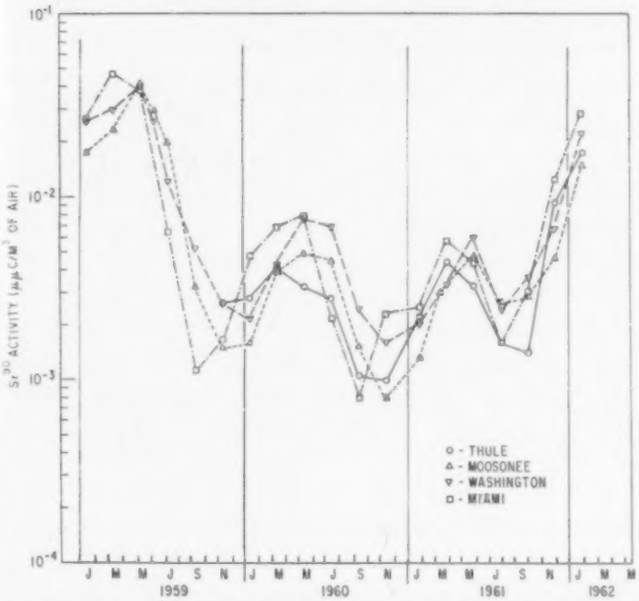

FIGURE 2.—CONCENTRATIONS OF STRONTIUM–90 IN THE AIR OF THE NORTH TEMPERATE ZONE, 1959–1961

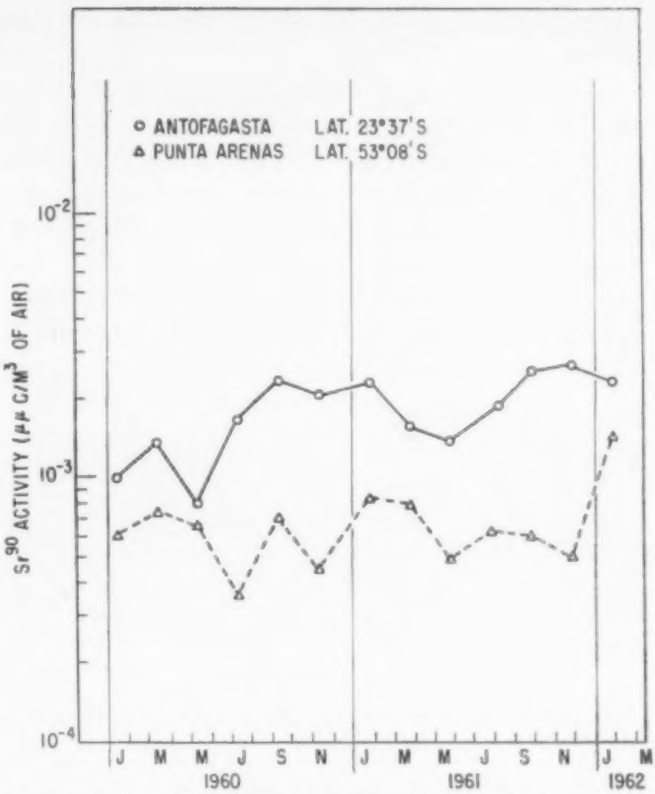

FIGURE 3.—CONCENTRATIONS OF STRONTIUM–90 IN THE AIR AT ANTOFAGASTA AND PUNTA ARENAS, CHILE, 1960–1961

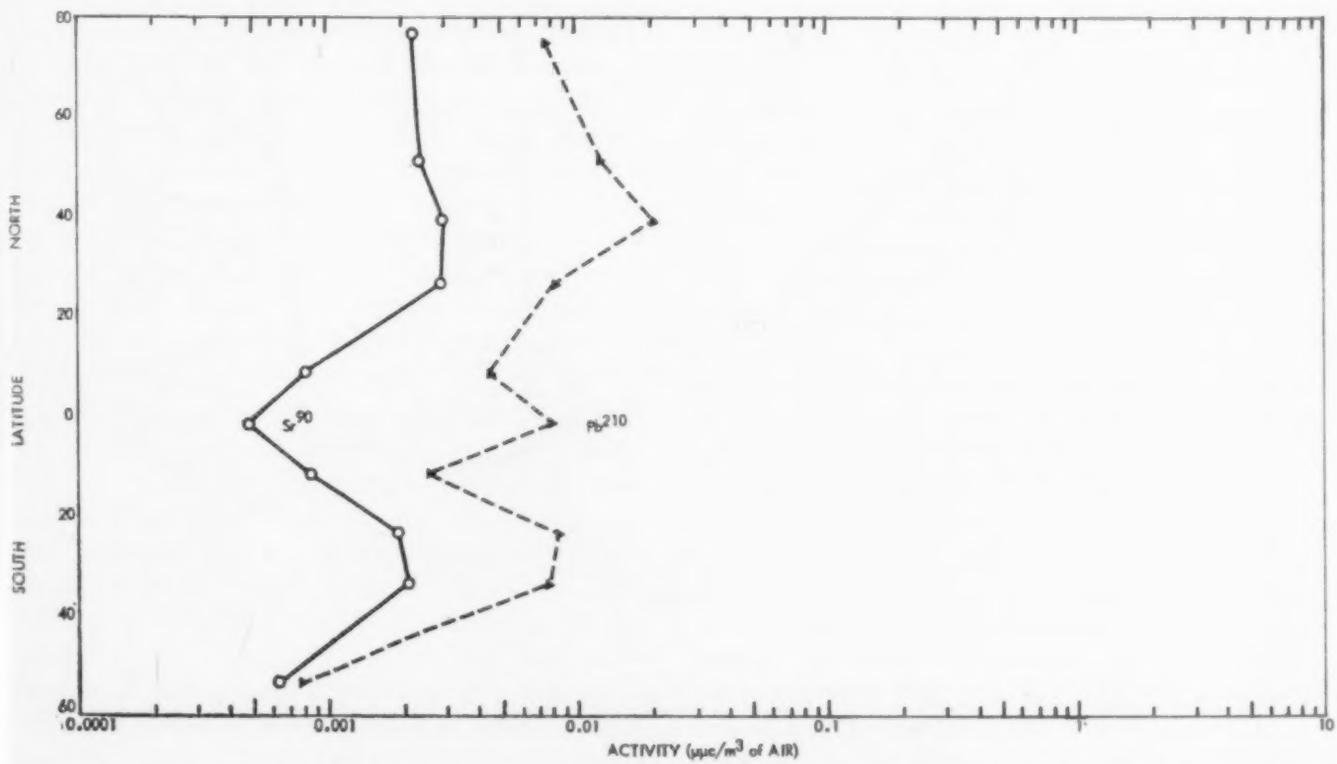

FIGURE 4.—PROFILES OF AVERAGE STRONTIUM–90 AND LEAD–210 CONCENTRATIONS DURING THE PERIOD SEPTEMBER 1960–AUGUST 1961

debris was injected directly into the stratosphere.

The strontium–90 concentrations at Antofagasta and Punta Arenas, Chile (see figure 3) show a gradual increase during the period 1960 through 1961 with definite indications of spring maxima in activity at Antofagasta. The peak-to-trough ratio is not as great there as at the Northern Hemisphere sites; at Punta Arenas there appears to be a more random fluctuation of activity with time.

Lead–210 in the Air

Lead–210, a natural radioactive isotope resulting from decay of radon in the air, has been measured in air filter collections during the past several years. Large month-to-month variations have been observed as well as a definite latitude dependence of lead–210 concentration which resembles that of strontium–90. During the year September 1960 to August 1961, the lead–210 content of air was generally much higher than its strontium–90 content at all sites, as indicated in the strontium–90 and lead–210 profiles shown in figure 4.

Activity Ratios

Under certain conditions the relative concentrations of radioisotopes can be used to determine the age of debris appearing at the different sites; generally, due to the mixing of debris from various sources, this "apparent" age is often of limited usefulness in identifying the source. This is a real problem in the bimonthly collections particularly when more or less coherent clouds of radioactivity are passing rather rapidly over the collecting sites. The variations in the relative concentrations

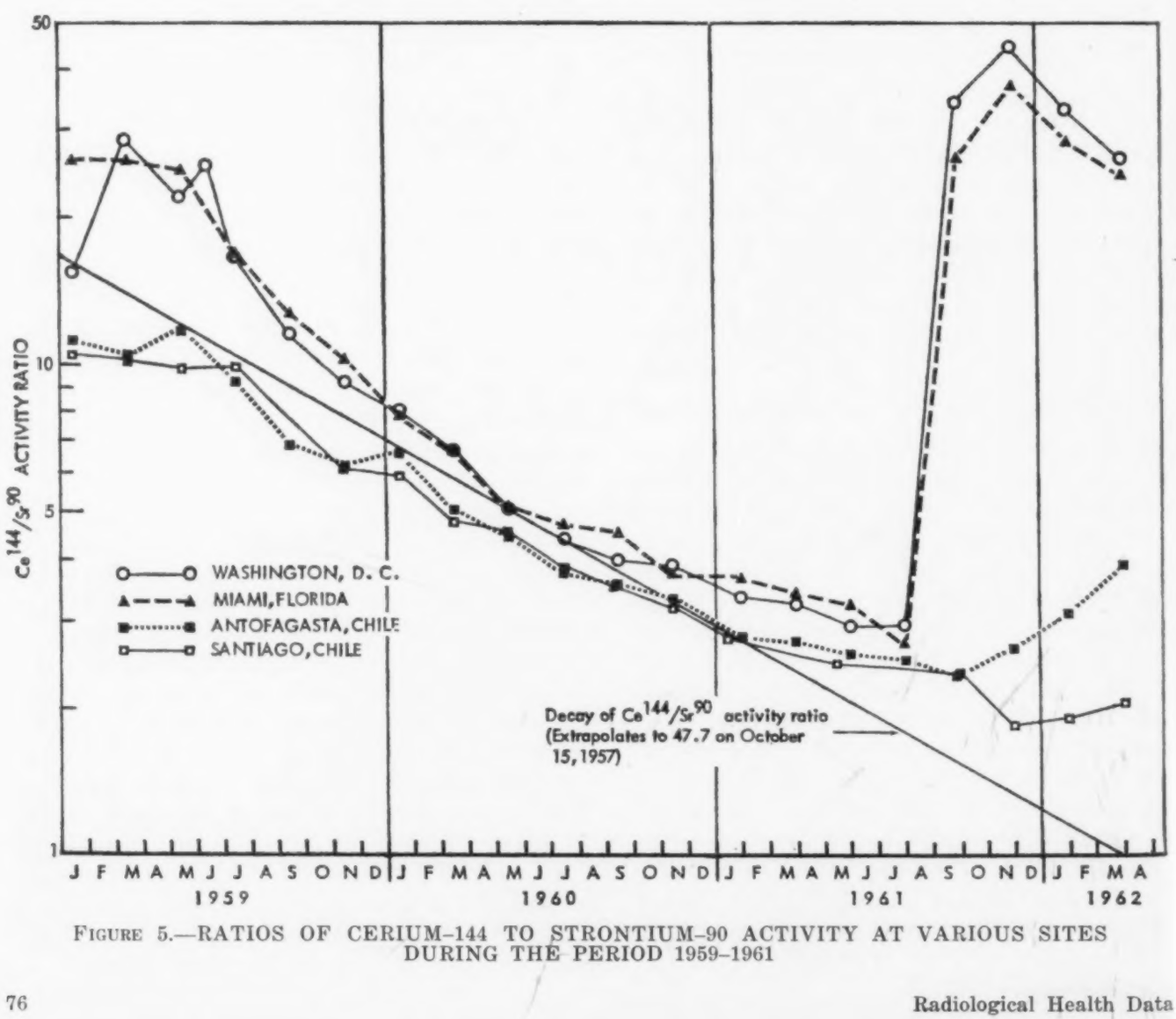
50
10
5
1
Ce^{144}/Sr^{90} ACTIVITY RATIO
WASHINGTON, D. C.
MIAMI, FLORIDA
ANTOFAGASTA, CHILE
SANTIAGO, CHILE
Decay of Ce^{144}/Sr^{90} activity ratio (Extrapolates to 47.7 on October 15, 1957)
J F MA M J J A S O N D J F MA M J J A S O N D J F MA M J J A S O N D J F MA
1959
1960
1961
1962

FIGURE 5.—RATIOS OF CERIUM–144 TO STRONTIUM–90 ACTIVITY AT VARIOUS SITES DURING THE PERIOD 1959–1961

of individual radioisotopes, however, can indicate whether the sources of debris at the different sites are the same or different.

An example of the changes in isotope ratios with time is given in figure 5, where the Ce^{144}/Sr^{90} activity ratios for a number of sites are shown for the period 1959–1961. The apparent aging of the debris in the Northern Hemisphere during 1959–1960 is due to the more rapid deposition of the younger debris. In contrast, the apparent decrease in age during the period 1960–1961 in both hemispheres must be due to the influx from the stratosphere of debris younger than the average. Since this change is effective in both hemispheres it must be due to debris introduced high into the stratosphere over the tropics, presumably from the "Teak" and "Orange" shots of the U.S. Hardtack series. The abrupt change occurring in late 1961 at the Northern Hemisphere sites is, of course, due to the fall 1961 series of high yield tests in the U.S.S.R.

In most respects the cesium–137 activity concentrations parallel those of the strontium–90 concentrations but are about 1.9 times as high. Variations in the cesium–137 concentrations relative to strontium–90 and to that of other activities at a few sites indicate that fractionation of cesium–137 has occurred either in nature or in the sampling and analytical process. The Ce^{144}/Pm^{147} concentrations show a progressive change with time that suggests generally uniform mixing of these isotopes prior to the time of influx of fresh debris from the 1961 U.S.S.R. tests. Promethium–147 is not as useful as cerium–144 in such measurements, however, because of the larger errors inherent in measuring the low energy beta activity emitted by promethium–147.

Following the resumption of large scale testing by the U.S.S.R. in September 1961, such isotopes as Ce^{141}, Sr^{89} and Y^{91}, which had been absent from collections for many months, appeared in quantity at the Northern Hemisphere sites. The ratios of these isotopes to each other and to longer lived isotopes indicated the youthfulness of the debris; however, due to the length of the collections reported here and the close spacing of the nuclear tests, no assignment of debris to particular tests is warranted.

An indication of the relative quantities of fresh and old debris appearing at the various sites during November–December 1961 is given in figure 6, where the latitudinal profiles of cerium–141 (33.1-day half-life), strontium–89 (50.5-day half-life), and strontium–90 (27.7 year half-life) concentrations along the 80th Meridian are shown. The highest concentrations of cerium–141 and strontium–89 in the Southern Hemisphere were at Guayaquil and in the neighborhood of Chacaltaya and Antofagasta, where they were less than 1 percent of those observed at similar latitudes in the north. Similar results were obtained from collections made in early 1962. Transequatorial mixing to this extent is not unexpected since a similar transfer of debris from the first French test in the Sahara at 27° north latitude to the Southern Hemisphere has been observed (*3*).

Summary

Prior to September 1961 the fission product content of the tropospheric air in the Northern Hemisphere continued at a decreasing rate the downward trend observed since 1959, with well-defined seasonal increases associated with the spring maximum in transport of debris from the stratospheric reservoir. In the Southern Hemisphere, seasonal variations were not so pronounced and a trend toward increasing air concentrations of long-lived fission products was observed. There were suggestions from changes in certain activity ratios that debris from the high altitude shots of 1958 was appearing in both hemispheres.

The resumption of nuclear testing by the U.S.S.R. in September 1961 caused an immediate hundredfold increase in the gross beta activity in the Northern Hemisphere; the increase in strontium–90 was more gradual and reached a maximum in early 1962, where its concentration was about ten times that of the previous year. Use of the shorter-lived fission products as tracers indicated a small but measurable transfer of activity to the Southern Hemisphere with a large gradient in activity near the equator.

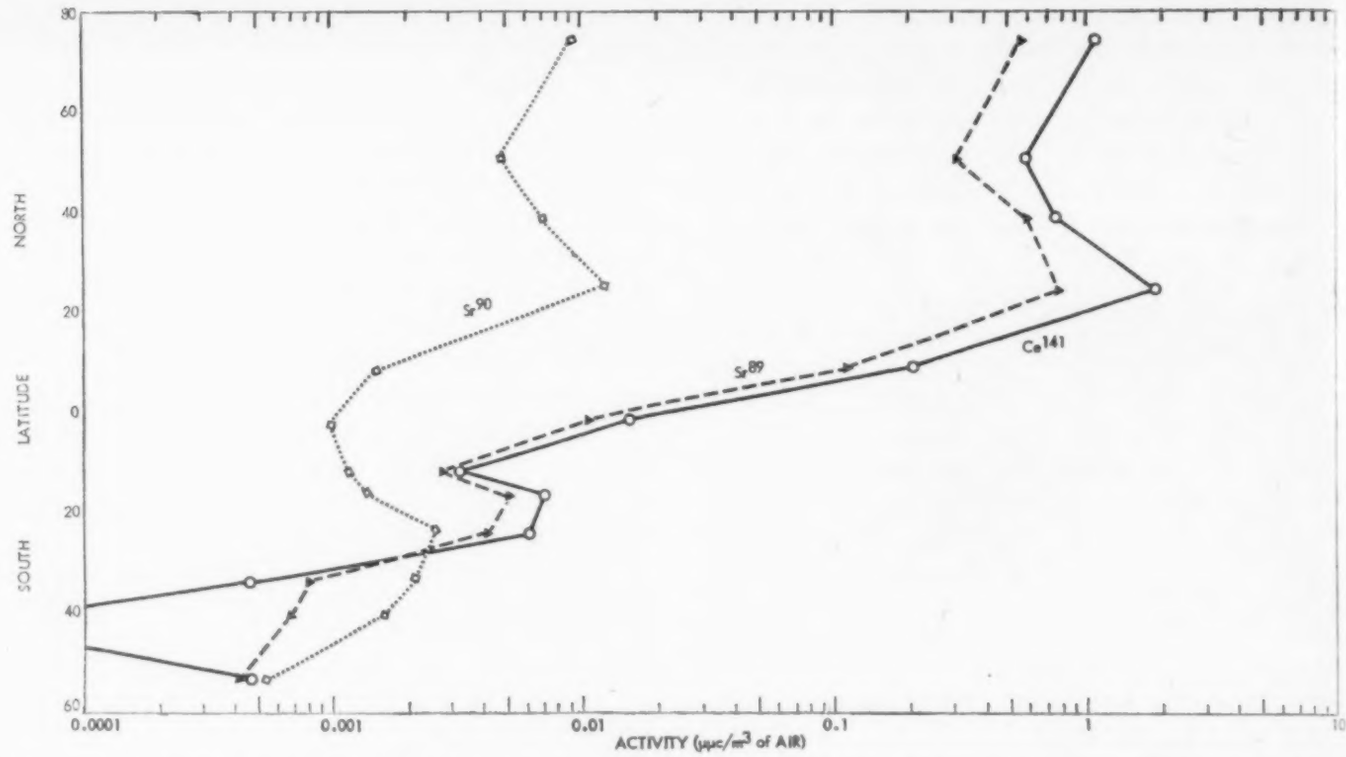

FIGURE 6.—PROFILES OF THE ACTIVITY CONCENTRATIONS OF CERIUM–141, STRONTIUM–89 AND STRONTIUM–90 IN THE AIR AT GROUND LEVEL ALONG THE 80TH MERIDIAN (WEST) DURING THE PERIOD NOVEMBER–DECEMBER 1961

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(*2*) Lockhart, L. B., Jr., R. L. Patterson, Jr., A. W. Saunders, Jr., and R. W. Black: *Fission Product Radioactivity in the Air Along the 80th Meridian (West) During 1961, NRL Report 5869* (in press).

(*3*) Lockhart, L. B., Jr., R. L. Patterson, Jr., A. W. Saunders, Jr., and R. W. Black: *Fission Product Radioactivity in the Air Along the 80th Meridian (West) During 1960, NRL Report 5692,* Washington, D.C. (October 1961).

SECTION II.—FOOD

Stable Strontium in Tri-City Diets*

February–July 1961

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

One facet of the program of investigation at the Health and Safety Laboratory on the passage of strontium–90 through food chains to man has been the determination of the concentrations of stable strontium present in the various components of the food chain and in man's skeleton. To obtain part of this information, three sets of ashed foods, consisting of 19 samples each from the Health and Safety Laboratory's Tri-City Diet Studies (*1*), were analyzed for stable strontium to estimate the yearly intake of this element by residents of New York City, Chicago, and San Francisco. The results of the analyses and the estimate of annual dietary intake are presented in table 1. In general, the greatest contributions of stable strontium to the diet were from milk and fresh fruit.

* Data from *Quarterly Summary Report, HASL–131*, October 1, 1962.

TABLE 1.—STABLE STRONTIUM LEVELS OF DIET

Food Category	Consumption (kg/yr)	New York City February 1961		San Francisco March 1961		Chicago July 1961	
		Concentration (mg Sr/kg food)*	Intake (mg Sr/yr)	Concentration (mg Sr/kg food)*	Intake (mg Sr/yr)	Concentration (mg Sr/kg food)*	Intake (mg Sr/yr)
Bread, white	37	2.06	76.3	2.15	79.7	2.38	88.1
Bread, whole wheat	11	2.24	24.6	2.68	29.5	2.64	29.0
Eggs	16	1.20	19.1	1.31	20.9	1.29	20.6
Vegetables, fresh	43	1.53	65.8	2.32	99.8	1.67	71.8
Vegetables, root	17	2.30	39.1	5.04	85.7	4.37	74.3
Milk	221	0.38	82.9	1.00	220.8	0.30	66.3
Chicken	17	0.33	5.6	0.23	3.9	0.22	3.7
Fish, fresh	8	9.43	75.4	3.45	27.6	2.16	17.3
Flour	43	0.51	22.1	0.64	27.7	0.78	33.5
Macaroni	3	0.48	1.4	0.88	2.6	0.59	1.8
Rice	3	0.19	0.6	0.21	0.6	0.19	0.6
Meat	73	0.18	13.0	0.19	14.0	0.21	15.3
Fish, shell	1	18.17	18.2	3.59	3.6	5.39	5.4
Beans, dried	3	2.81	8.4	3.47	10.4	3.69	11.1
Fruit, fresh	68	1.09	73.8	8.82	599.8	0.07	354.2
Potatoes	45	0.31	14.1	1.09	48.8	0.67	30.2
Fruit, canned	26	0.36	9.3	0.26	6.7	0.23	6.0
Fruit, juices	19	0.37	7.1	0.45	8.3	1.09	20.7
Vegetables, canned	20	1.54	30.7	0.32	6.4	1.88	37.6
Total diet	674	0.872	587.5	1.92	1,296.8	1.32	887.5

* Fresh weight

Most of the analyses were done by emission spectroscopy by a commercial laboratory. The average difference between a large number of blind duplicate samples analyzed by this laboratory was ± 5 percent. Many of the samples were also analyzed by other laboratories using different methods (flame photometry and neutron activation analysis). All results agreed to within 10 percent except for a few isolated cases.

Assuming an average annual calcium intake of 383 grams (*2*) and using the data in table 1, the ratio of stable strontium to calcium in the average diet is found to be 1.5 mg Sr/g Ca, 2.3 mg Sr/g Ca, and 3.4 mg Sr/g Ca in New York City, Chicago, and San Francisco diets, respectively. These results may be compared with the estimates of 1.3 mg Sr/g Ca for diets in the United Kingdom (*3*), 1.3 mg Sr/g Ca for diets in Canada (*4*), and 1.2 mg Sr/g Ca for a typical Danish diet (*5*).

The Danish study showed that there was a seasonal variation in the dietary intake of stable strontium of a factor of two between the spring and autumn, the intake during the spring being greater. Preliminary measurements at this laboratory show considerable variability in the stable strontium content of some foods purchased at different times. In view of these findings, the estimates of stable strontium intake in the three cities presented here should be taken as provisional since more measurements of samples collected throughout the year will have to be made before a true yearly average intake can be computed.

If the dietary intake of stable strontium in New York City does differ from that in San Francisco by about a factor of two, as it now appears, then one would expect stable strontium levels in bone samples obtained from deceased residents of these cities to also differ by a factor of two. Measurements of stable strontium in human bone samples from these cities are now being made, in addition to the analyses of foods, to see if this is the case. The data will also be used to calculate the ratio Sr/Ca in diet to Sr/Ca in bone (Observed Ratio) and to see if this Observed Ratio varies with the total dietary strontium intake.

Previous coverage in *Radiological Health Data:*

Period	Issue
Third sampling (October 1960–January 1961)	*October 1961*
Fourth sampling (February–April 1961)	*December 1961*
Fifth sampling (May–July 1961)	*March 1962*
Sixth sampling (August–October 1961)	*June 1962*
Seventh sampling (November 1961–February 1962)	*September 1962*
August–October 1961 (stable strontium and strontium–90)	*November 1962*
November 1961–February 1962 (strontium–90)	*January 1963*

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(*2*) U.S. Atomic Energy Commission: Strontium–90 in U.S. Diets, 1960, *Fallout Program Quarterly Summary Report, HASL–113*:85, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1961), price $2.50.

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(*5*) Aarkrog, A., et al.: *Environmental Radioactivity in Denmark, Riso Report No. 41,* (June 1961).

Cesium–137 and Strontium–90 in Foods
1960–1962

Division of Pharmacology, Food and Drug Administration

As a part of a continuing program for surveillance of foodstuffs by the Food and Drug Administration (FDA), cesium–137 analyses are performed on about 10 percent of all samples analyzed for strontium–90. Details of the overall program have previously been described (*1*). The unashed samples are split, with one-half being assayed in the Washington, D.C. laboratory for cesium–137 and one-half being assayed in the respective FDA District laboratory for strontium–90.

Cesium–137 Analysis

The sample splits to be analyzed for cesium–137 are chopped up or slurried without ashing or further chemical preparation and placed in a 3.7-liter Marinelli beaker. The beaker with its slurried contents is placed directly over a 3 x 3-inch sodium iodide crystal and counted for 1000 minutes with a 400-channel (0–2 Mev) gamma spectrometer previously calibrated with a cesium–137 standard. By integrating the number of counts in the peak characteristic of cesium–137 (0.66 Mev), and subtracting for background and the influence of adjacent peaks, the concentration of cesium–137 in the sample can be determined.

Strontium–90 Analysis

The sample splits to be analyzed for strontium–90 are ashed at 550–600° C and dissolved in hydrochloric acid. Calcium and strontium are precipitated as oxalates and separated with concentrated nitric acid. Radium is removed with barium chromate, and the lanthanides are removed with yttrium hydroxide. Strontium–90 is then determined by isolation of the yttrium–90 daughter product at secular equilibrium. The direct measurement of strontium–90 with correction for ingrowth of yttrium–90 is not used since it does not differentiate between strontium–90 and strontium–89, which are part of the fresh fallout in the environment following nuclear weapons testing.

Results

The results of 182 analyses for cesium–137 and, where available, the corresponding strontium–90 results are presented in table 1. Also included is the ratio of cesium–137 to strontium–90 to the nearest whole number. Because of the relatively small number of samples for individual food items, it is not possible to draw any inferences regarding geographical and temporal relationships. The effect of processing on the cesium–137 and strontium–90 content of vegetables is shown in table 2. Again, the number of samples is small. Table 3 presents the distribution of cesium–137 and strontium–90 in plant parts.

Discussion

Generally, the cesium–137 concentration in foods is higher than the strontium–90 concentration. The only exception is cassia (cinnamon bark). Also, there is a rough correlation of cesium–137 with strontium–90, i.e. in some products when the strontium–90 content is high, the cesium–137 content is high. However, it should be noted that this correlation is at best approximate and that exceptions appear upon closer scrutiny. The cesium–137—strontium–90 ratio can be observed to vary widely.

Among the vegetables, the green leafy varieties contain more cesium–137 than other products. The strontium–90 content of these same varieties is also high.

Corn contains the lowest cesium–137 and strontium–90 concentrations among all grains analyzed. Barley, rice, and rye contain the highest concentrations of cesium–137, and wheat contains the highest strontium–90 concentrations.

Among the beverage products, tea leaves contain the most cesium–137 and strontium–90.* Cacao beans contain about the same

* FDA studies indicate an extraction factor of 0.2 for strontium–90 in tea. Two grams of tea (the usual amount used in brewing a cup), containing the maximum nuclide content in table 1, would yield 0.4 pc of strontium–90 per cup of liquid tea. At present, studies are under way to determine the extraction factor for cesium–137 in tea.

TABLE 1.—CESIUM-137 AND STRONTIUM-90 IN FOODS

Variety	Number of samples	Cesium-137 (pc/kg)		Strontium-90 (pc/kg)		Cs^{137}/Sr^{90} [a]
		Average	Range	Average	Range	
Vegetables						
Beans, kidney (dried)	4	288	276- 311	3.0	2.2- 3.0	96
Beans, lima	3	159	119- 210	12	1.0- 28	13
Beans, navy	1	1943	[b]	[c]—		
Beans, pinto (dried)	2	292	276- 307	6.0		49
Beans, snap	3	50	36- 70	22	14 - 30	2
Blackeyed peas	3	250	195- 309	1.0		250
Broccoli	2	148	111- 185	12	10 - 14	12
Brussel sprouts	1	125		6.0		21
Cabbage	5	437	[d]ND-1030	6.0	4.0- 9.0	73
Collards	1	511		47		109
Mustard greens	1	3990		91		44
Parsley	3	4680	3210-5540	86	64 - 127	55
Peas (canned)	1	31		1.0		31
Soybeans	6	446	303- 674	26	18 - 34	17
Spinach	5	1800	569-3180	40	32 - 55	45
Root vegetables						
Carrots	1	51		—		
Potatoes, sweet	1	107		5		21
Potatoes, white	2	104	73- 135	1.0		104
Turnips	1	413		5.4		77
Fruits						
Apples	1	44		—		
Cherries	1	236		—		
Cranberries	1	562		—		
Dates	2	141	130- 152	—		
Figs	4	189	168- 237	7.7	7.0- 9.0	25
Grapefruit	1	51		1.0		51
Nectarines	1	57		—		
Oranges	2	96	51- 140	3.0		32
Peaches (canned)	1	553		0.2		2765
Pumpkin	1	90		2.7		33
Raspberries (red)	1	372		—		
Tomatoes	1	38		—		
Grains						
Barley	5	204	159- 228	15.6	7.0- 23	13
Corn	8	88	71- 120	1.2	0.2- 3.7	73
Oats	7	122	87- 150	15	4.8- 26	8
Rice	1	329		2.5		132
Rye	5	203	157- 243	14		14
Wheat	11	178	76- 561	17	0.9- 53	10
Eggs						
Shells	1	1170		390		3
Substance	3	19	3- 27	1.5	0.7- 2.4	13

TABLE 1.—CESIUM-137 AND STRONTIUM-90 IN FOODS—Continued

Variety	Number of samples	Cesium-137 (pc/kg)		Strontium-90 (pc/kg)		Cs^{137}/Sr^{90} [a]
		Average	Range	Average	Range	
Seafoods						
Clams	1	153		0.5		306
Crabmeat	1	120		—		
Haddock	1	40		—		
Sardines	2	87	80- 94	0.9		97
Shrimp	1	6.0		1.2		5
Tuna (canned)	3	105	73- 123	0.2	0.1- 0.4	525
Beverage products						
Cacao beans	2	540	323- 757	15	12 - 18	36
Coffee	7	431	320- 652	12	5.4- 25	36
Tea	9	1770	924-4960	299	29 -1034	6
Nuts						
Brazil nuts	2	942	705-1180	77		12
Peanuts	2	168	111- 226	58		3
Pecans	7	419	230- 860	29		14
Walnuts	1	112		1.2		93
Spices						
Cassia	1	1130		2590		0.4
Cardamom	2	843	765- 921	160	98 - 223	5
Cloves	2	1320	1140-1490	—		
Hops (dried)	1	633		50		13
Mustard seed	4	246	168- 410	54	32 - 92	5
Thyme leaves	1	3150		885		4

[a] Calculated to the nearest whole number.
[b] Blank indicates no variance.
[c] Dash indicates no strontium-90 analysis was done.
[d] ND indicates cesium-137 not detectable.

TABLE 2.—EFFECT OF PROCESSING ON CESIUM-137 AND STRONTIUM-90 CONTENT

	Broccoli		Spinach	
	Raw	Canned	Raw	Frozen
Number of samples	2	2	2	2
Cesium-137 (pc/kg)				
average	148	67	1415	905
range	111-185	47 -87	569- 2,260	240-1,570
Strontium-90 (pc/kg)				
average	12	7.5	43.5	25.5
range	10- 14	5 -10	32 - 55	15- 36

TABLE 3.—DISTRIBUTION OF CESIUM-137 AND STRONTIUM-90 IN PLANT PARTS

Product	Cesium-137			Strontium-90		
	Average (pc/kg)	Range (pc/kg)	Number of samples	Average (pc/kg)	Range (pc/kg)	Number of samples
Apples						
core	—[a]			3.8	0.8– 14	14
flesh	—			0.8	0.1– 2.6	15
peel	—			1.4	0.6– 3.5	8
Beans, lima						
beans	134	119–149	2	8.5	0.6– 28	25
pods	52	46– 57	2	44	3.7–172	25
Corn						
kernel	83	72– 90	3	0.9	0.3– 1.4	3
meal	73	35–105	3	3.0	0.0– 6.0	2
Eggs						
shells	1170		1	390		1
substance	3		1	1.5		1
Rice						
paddy	329		1	2.5		1
milled	22		1	0.2		1
Wheat						
berry	115	80–150	2	25	3.3– 58	25
bran	369	273–465	2	64	9.6–136	24
flour	45	31– 59	2	5.5	0.6– 24	25

[a] Dash indicates cesium-137 analysis was not done.

amounts of cesium–137 and strontium–90 as coffee beans.

Brazil nuts contain the most cesium–137 and strontium–90 of all the nuts analyzed. The one sample of walnuts contained the least concentrations of both radionuclides.

Of the spices analyzed, thyme leaves are highest in cesium–137, followed by cloves and cassia. Cassia contains the most strontium–90, followed by thyme leaves. The spice products contribute very little to the radionuclide intake in the total diet.

Table 2 shows in a limited respect the effect of processing on the cesium–137 and strontium–90 content of two vegetables items. In both cases the steps in processing reduce the radionuclide content by over 20 percent.

Table 3 shows the distribution of cesium–137 and strontium–90 in plant parts. Cesium–137 analyses are not available for apples. In all cases, except lima bean pods, the cesium–137 concentration is higher than the strontium–90 concentration in the same plant part. It can be theorized that while the cesium–137 in the pods is a result of direct deposition of fallout, the cesium–137 in the bean resulted from translocation. It is important to note that the bean has a high potassium content, as does most seed tissue. Cesium–137 follows the metabolic pathways of potassium.

Of interest is the observation that the distribution of cesium–137 between eggshells and egg substance is similar to the distribution of strontium–90 between eggshells and egg substance. In each case, the concentration of nuclide in the shell is much greater than that in the substance.

Summary

The results of analyses for cesium–137 in a number of food items are presented with avail-

ble strontium–90 analyses on the same sample. In general, the cesium–137 concentration is higher than the strontium–90 concentration. The effect of washing and other procedures in the preparation of the canned or frozen product is tabulated. The distribution of cesium–137 in plant parts follows the same general relationship as strontium–90 except in those tissues high in potassium.

Recent coverage in *Radiological Health Data:*

Period	Issue
1960 and 1962	*May 1962*
1961	*June 1962*
1960–1962	*August 1962*
1960–1962	*September 1962*
1959–1961 (Baby Food)	*November 1962*
1960–1962	*December 1962*

REFERENCE

(*1*) Food and Drug Administration: Survey of Radioactivity in Food, *Radiological Health Data, 3*:476–81 (December 1962).

SECTION III.—MILK

Milk Surveillance

Milk has been the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because milk is a basic constituent of the diet of the U.S. population and contains most of the radionuclides identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

It should be remembered that milk is only one of many dietary sources of radionuclide intake.

PASTEURIZED MILK NETWORK
October 1962

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

In 1957, the PHS began analyzing raw milk to determine relationships between dairy practices and radionuclide levels in milk. However, it became evident that the milk actually consumed by the population should be included in a broader sampling program. In 1960, the pasteurized milk network was initiated to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in pasteurized milk monitoring. Since June 1961, raw milk sampling has been carried out for investigative rather than monitoring purposes.

During October 1962, pasteurized milk surveillance was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies which have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis. Publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, radioanalysis of strontium, data compilation, and publication procedures. Data from gamma analyses (iodine–131) are available to State public health officials and the Federal Radiation Council within 3 days after sample collection for possible countermeasure purposes.

Sampling and Compositing Procedures

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all States and additional points when indicated by widely varying conditions of the milk supply or when needed in order to

over large population groups. Each sample is composited from subsamples collected from each plant in proportion to the relative volumes of milk sold. The objective of this sampling program is to reflect about 90 percent of each city's milk supply. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling frequency has been increased. During October 1962, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Iodine–131, cesium–137, and barium–140 are determined by gamma scintillation spectroscopy,[1] while strontium–89 and strontium–90 are determined following radiochemical separation. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for October 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Discussion of the Data

The iodine–131 October 1962 monthly average concentration contour map (figure 1) is similar to the September contour map appearing in the January issue. Most of the country reported monthly averages of between 10 and 100 μμc/liter. Values of 90 to 140 μμc/liter were observed in the Great Lakes region. Palmer, Alaska, had the highest October average of 270 μμc/liter while the network average was 61 μμc/liter.

The monthly average strontium–89 concentrations in milk for October 1962 (figure 2) increased from the previous month at a number of stations. The network average for the month was 56 μμc/liter. Monthly average concentrations slightly greater than 100 μμc/liter were noted in Minnesota, Iowa, and in the northwestern corner of the United States. Phoenix, Arizona, which very seldom shows monthly average strontium–89 concentrations greater than 20 μμc/liter, reported 50 μμc/liter for October. Palmer, Alaska reported 150 μμc/liter—the highest average for the month.

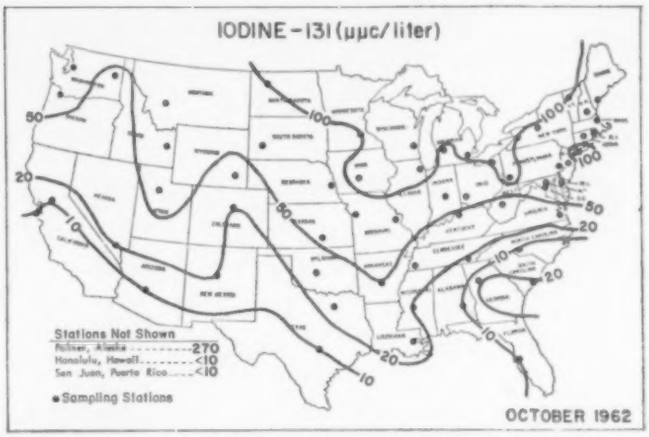

FIGURE 1.—IODINE–131 CONCENTRATIONS IN PASTEURIZED MILK

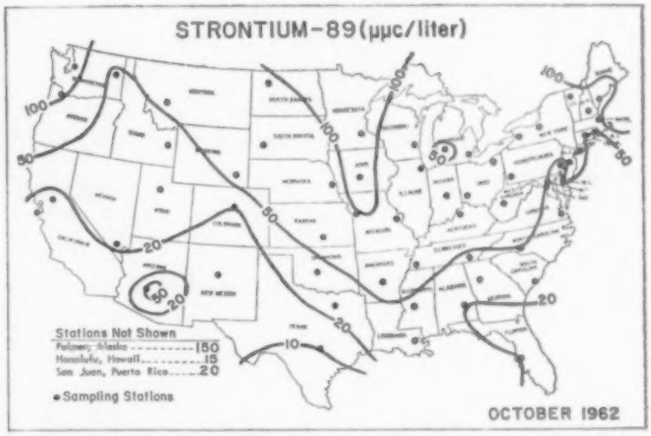

FIGURE 2.—STRONTIUM–89 CONCENTRATIONS IN PASTEURIZED MILK

The October 1962 monthly average strontium–90 concentration contour map (figure 3) appeared to be similar to the map for the previous month. The network average rose from 12 to 16 μμc/liter during October. The Southwest had concentrations below 10 μμc/liter while several northern States west of the Mississippi River reported values over 20 μμc/liter. Other areas reporting values greater than 20 μμc/liter were the lower Mississippi Valley re-

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

gion and the inland areas of the Atlantic seaboard States. A station high of 29 μμc/liter was noted in Seattle, Washington.

Selected Monthly Strontium–90 Profiles

In previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from selected cities in the monitoring program were published. Profiles for an additional 15 cities are presented in figure 4. These graphs show the strontium–90 concentrations in milk from selected cities in the United States Department of Agriculture marketing regions of the United States.

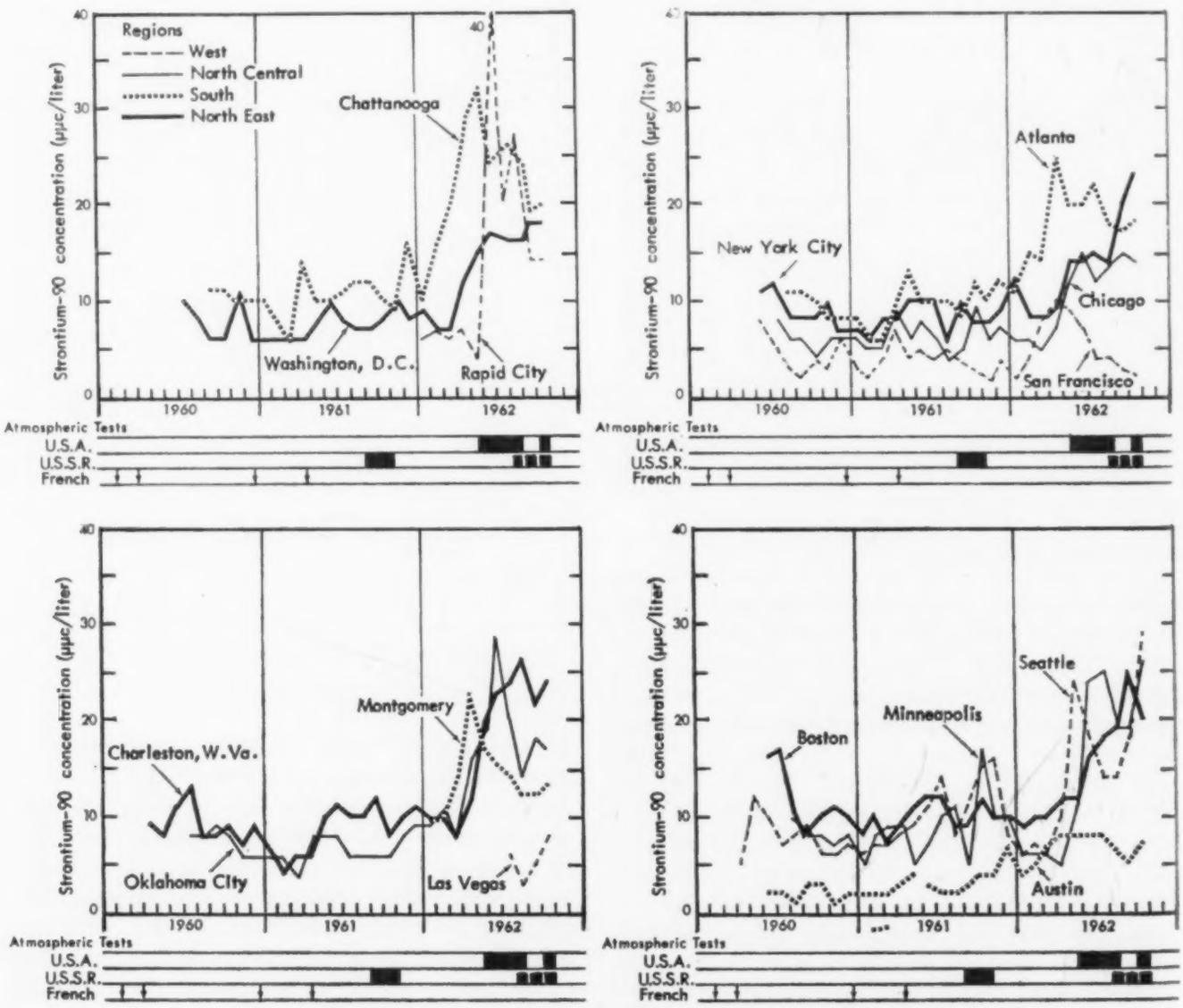

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 1.—RADIOACTIVITY IN PASTURIZED MILK, OCTOBER 1962

[Average radioactivity concentrations in $\mu\mu c$/liter]

Sampling locations	Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Last Sr^{90} Profile in RHD
	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	
Ala: Montgomery	1.22	1.23	35	20	13	13	10	10	35	25	10	10	Feb. 1963
Alaska: Palmer	1.08	1.34	75	150	12	16	250	270	55	65	30	60	Nov. 1962
Ariz: Phoenix	1.08	1.31	10	50	2	7	10	10	15	20	10	<10	Jan. 1963
Ark: Little Rock	1.21	1.24	80	70	29	28	10	50	55	50	20	20	Nov. 1962
Calif: Sacramento	1.11	1.34	5	15	3	4	20	10	20	15	20	10	Dec. 1962
San Francisco	1.13	1.32	10	5	4	2	20	10	20	20	20	10	Feb. 1963
Colo: Denver	1.11	1.38	55	20	15	13	30	20	75	50	10	<10	Dec. 1962
Conn: Hartford	1.10	1.15	30	50	12	12	30	70	70	60	<10	20	Dec. 1962
Del: Wilmington	1.09	1.15	40	50	13	14	30	70	70	60	<10	20	Jan. 1963
D.C: Washington	1.16	1.16	45	50	17	18	20	60	60	50	10	20	Feb. 1963
Fla: Tampa	1.23	1.24	20	20	11	9	<10	10	145	130	<10	<10	Jan. 1963
Ga: Atlanta	1.23	1.23	45	30	19	18	20	20	55	50	10	20	Feb. 1963
Hawaii: Honolulu	1.07	1.32	10	15	4	8	10	<10	35	35	<10	10	Nov. 1962
Idaho: Idaho Falls	1.09	1.34	45	30	11	13	40	40	75	70	20	10	Jan. 1963
Ill: Chicago	1.14	1.14	35	60	14	14	50	120	60	55	<10	20	Feb. 1963
Ind: Indianapolis	1.11	1.19	40	65	16	14	30	90	40	45	<10	20	Dec. 1962
Iowa: Des Moines	1.10	1.34	80	105	14	16	60	120	40	50	20	20	Jan. 1963
Kans: Wichita	1.12	1.34	60	60	13	13	40	60	40	40	10	10	Nov. 1962
Ky: Louisville	1.19	1.20	75	65	22	24	20	40	35	30	20	30	Jan. 1963
La: New Orleans	1.22	1.26	75	45	30	24	10	30	80	50	20	20	Nov. 1962
Maine: Portland	1.15	1.13	45	75	15	19	30	60	120	120	<10	20	Jan. 1963
Md: Baltimore	1.16	1.21	40	50	18	18	20	60	60	65	<10	20	Jan. 1963
Mass: Boston	1.12	1.20	45	100	21	20	30	90	125	115	10	30	Feb. 1963
Mich: Detroit	1.10	1.16	35	70	12	16	50	120	70	70	<10	20	Dec. 1962
Grand Rapids	1.15	1.22	35	45	10	11	40	90	60	60	<10	20	Jan. 1963
Minn: Minneapolis	1.10	1.39	85	120	21	26	40	100	95	100	20	40	Feb. 1963
Miss: Jackson	1.26	1.28	70	40	21	21	10	20	45	30	20	20	Dec. 1962
Mo: Kansas City	1.07	1.33	80	100	14	17	50	80	35	40	20	30	Dec. 1962
St. Louis	1.08	1.34	60	55	16	16	40	60	40	40	20	20	Nov. 1962
Mont: Helena	1.14	1.35	80	55	15	19	50	70	85	85	20	20	Nov. 1962
Nebr: Omaha	1.12	1.33	85	70	14	13	60	80	50	50	20	20	Nov. 1962
Nev: Las Vegas	1.06	1.29	25	25	5	8	30	20	35	30	<10	10	Feb. 1963
N.H: Manchester	1.13	1.17	45	80	17	23	30	70	145	110	<10	20	Sep. 1962
N.J: Trenton	1.12	1.14	35	65	12	14	20	60	65	60	<10	20	Dec. 1962
N. Mex: Albuquerque	1.10	1.37	20	15	5	6	30	20	25	25	10	20	Nov. 1962
N.Y: Buffalo	1.10	1.12	35	65	15	14	40	90	70	75	<10	20	Dec. 1962
New York	1.08	1.16	40	85	16	23	40	130	80	90	<10	40	Feb. 1963
Syracuse	1.11	1.16	40	75	12	19	40	100	60	60	10	30	Nov. 1962
N.C: Charlotte	1.23	1.24	55	50	23	21	<10	10	50	45	10	20	Nov. 1962
N.D: Minot	1.11	1.36	100	95	22	23	80	100	80	70	20	30	Jan. 1963
Ohio: Cincinnati	1.12	1.15	45	50	13	17	40	80	40	30	<10	<10	Dec. 1962
Cleveland	1.11	1.18	30	65	14	15	40	100	55	50	<10	10	Nov. 1962
Okla: Oklahoma City	1.16	1.20	60	40	17	17	20	30	45	35	10	20	Feb. 1963
Ore: Portland	1.12	1.42	60	110	12	20	20	60	65	85	10	40	Dec. 1962
Pa: Philadelphia	1.14	1.16	30	45	14	15	30	70	70	50	<10	10	Nov. 1962
Pittsburgh	1.12	1.17	40	60	18	23	30	110	85	70	<10	20	Nov. 1962
P.R: San Juan	1.19	1.16	25	20	11	7	<10	<10	35	30	10	<10	Nov. 1962
R.I: Providence	1.11	1.15	35	60	13	19	20	70	85	80	<10	20	Jan. 1963
S.C: Charleston	1.21	1.23	45	35	20	19	10	20	65	60	<10	20	Dec. 1962
S.D: Rapid City	1.06	1.13	85	60	20	14	70	80	60	60	20	20	Feb. 1963
Tenn: Chattanooga	1.25	1.26	65	45	23	20	10	20	55	40	10	20	Feb. 1963
Memphis	1.22	1.23	60	60	21	19	10	40	25	35	20	20	Jan. 1963
Tex: Austin	1.16	1.20	15	10	6	7	<10	10	20	15	<10	<10	Feb. 1963
Dallas	1.18	1.20	40	25	14	17	10	30	30	25	<10	10	Dec. 1962
Utah: Salt Lake City	1.10	1.36	60	30	12	10	320	60	95	90	40	30	Nov. 1962
Vt: Burlington	1.10	1.11	45	90	14	14	20	100	110	85	<10	20	Dec. 1962
Va: Norfolk	1.20	1.21	55	40	22	20	10	40	75	60	<10	20	Dec. 1962
Wash: Seattle	1.10	1.38	45	105	15	29	30	60	90	95	20	40	Feb. 1963
Spokane	1.15	1.42	40	40	14	15	50	40	70	75	10	10	Dec. 1962
W. Va: Charleston	1.16	1.19	80	65	24	24	20	30	45	50	10	20	Feb. 1963
Wis: Milwaukee	1.10	1.18	30	60	9	12	50	140	60	60	<10	20	Jan. 1963
Wyo: Laramie	1.11	1.36	125	60	15	13	190	30	110	80	50	20	Jan. 1963
Network average	1.14	1.25	49	56	14.8	16.0	40	61	62	58	12	20	

CALIFORNIA MILK NETWORK
1960–June 1962

State of California, Department of Public Health

Surveillance of the concentrations of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control, which started in 1960. Milk monitoring has been conducted by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation.

The surveillance program involves the weekly sampling of milk from 11 major milksheds (see figure 5). Originally, radioanalysis was performed for potassium–40, cesium–137, and strontium–90. More recently, interest has shifted to strontium–89, strontium–90, and iodine–131 and milk is now being analyzed for these three radionuclides only.

FIGURE 5.—CALIFORNIA MILKSHEDS

Results and Discussion

Table 2 summarizes the radioanalysis of milk from the 11 milksheds during the 1960–1961 period for potassium–40, cesium–137, and strontium–90. Table 3 presents strontium–89 and strontium–90 results for the same milksheds for the first six months of 1962. It should be noted that the units used in table 3 are μμc/g calcium. Comparisons of data between the two tables may be made using the approximate equivalent value of 1.1 gram of calcium per liter of milk. No iodine–131 data are given but occasional samples have indicated that only trace amounts of this radionuclide have been observed during this period.

Del Norte and Humboldt Counties have produced milk with relatively high (> 100 μμc/g calcium) strontium–89 concentrations compared to the other areas.

Del Norte County milk has the highest strontium–90 content of milk sampled in the State. The average for the first six months of 1962 is 26 μμc/liter. However, both these levels are well below those requiring protective action.

Milk from other California milksheds has exhibited much lower concentrations of strontium–90. Correlations made from data not reported here show that the level of contamination decreases generally as the total rainfall for the area decreases. Thus, as expected, the dryer southern part of the State has had less strontium–90 in milk.

Instrumentation and Methodology

Radioanalyses of the milk samples are carried out in the Sanitation and Radiation Laboratory. Counting of radiostrontium in chemically prepared samples is done in an automatic low-background anticoincidence counter. (Background counting rate is less than 1.5 counts per minute.) This system includes a hemispherical gas-flow (90 percent methane and 10 percent argon) Geiger-Mueller detector surrounded by a guard (anticoincidence) detector, about 600 pounds of steel shielding, an automatic sample changer, two scalers, and a printing-timer. The detector window thickness is 0.15 mg/cm^2. Counter efficiencies of 40 and 35 percent are realized for strontium–89 and strontium–90, respectively. The maximum capacity, using 60-minute counting times, is about 120 determinations in a normal week.

Three separate 256-channel analyzers are used for gamma pulse-height analysis. For this analysis, the 2″ x 2″ sodium iodide crystal

TABLE 2.—POTASSIUM-40, CESIUM-137, AND STRONTIUM-90 IN CALIFORNIA MILK BY SAMPLING AREA AND MONTH, 1960–1961

(Concentrations in $\mu\mu$c/liter)

Sampling Area	1960											
	January	February	March	April	May	June	July	August	September	October[a]	November[a]	December[a]
Fresno												
K^{40}	1,201	925	1,068	1,359	[b]	1,297			1,300	1,232		1,320
Cs^{137}	17	[c]	[c]	[c]					[c]	[c]		[c]
Sr^{90}	1.6	1.3	3.1	2.7	1.6	4.3	2.3	4.0	4.8	4.5	4.5	3.8
Humboldt												
K^{40}	1,196	1,045	1,173	1,170		1,120			1,413		1,160	1,190
Cs^{137}	31	35	24	26		[c]			[c]		[c]	[c]
Sr^{90}	4.2	4.9	7.3	4.4	6.3	3.1	5.3	5.1	4.3		4.4	5.7
Los Angeles												
K^{40}	1,219	1,041		1,288		1,130			1,390	1,280		1,320
Cs^{137}	18	12		4		7.8			[c]	[c]		[c]
Sr^{90}	2.7	2.1	4.9	1.1	1.2	1.0	3.2	2.5	1.0	3.2	2.8	3.2
Sacramento												
K^{40}		1,257	1,254	1,065	1,192				1,250			1,360
Cs^{137}		14	22	[c]	[c]				[c]			[c]
Sr^{90}	2.0	3.2	4.0	1.4	3.3	2.4	5.0	2.8	1.8	3.9	4.1	3.9
San Diego												
K^{40}	1,240	1,318	1,363	1,109	1,330				1,230	1,290		1,360
Cs^{137}	19.3	12	[c]	[c]	[c]				[c]	[c]		[c]
Sr^{90}	3.0	1.6	[c]	2.4	2.2	1.2	1.7	2.4	[c]2.4	1.7	4.1	2.9
Santa Clara												
K^{40}	1,190		1,130	1,161	1,380				1,260	1,250		
Cs^{137}	[c]		17	71	[c]				[c]	[c]		
Sr^{90}	2.7	2.3	2.9	1.1	2.6	2.1	3.3	1.9	2.4	1.4	2.7	2.0
Shasta												
K^{40}	1,241	1,274	1,297	1,249		1,189			1,686	1,240		
Cs^{137}	19	19	[c]	18.4		[c]			[c]	[c]		
Sr^{90}	2.0	3.7	2.5	3.9	2.9	3.3	4.0	5.2	5.4	2.4	2.6	2.2
Sonoma												
K^{40}	1,370		1,418	1,246					1,270		1,264	1,120
Cs^{137}	11		15	8	[c]				[c]		[c]	[c]
Sr^{90}	1.5	2.4	4.8	3.7	3.1	2.7	3.8	4.2	4.1	3.8	3.2	3.5

Sampling Area	1961											
	January	February	March	April	May	June	July	August	September	October[a]	November[a]	December[a]
Fresno												
K^{40}	1,320	1,440	1,320	1,260	1,435	1,147	1,426	1,352	1,303	1,298	1,350	1,209
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]			
Sr^{90}	2.06	1.65	1.91	1.41	2.30	1.74	1.09	1.44	1.15	1.58	1.52	1.58
Humboldt												
K^{40}	1,160	1,290	1,260	1,240	1,280	1,237	1,266	1,280	1,278	1,273	1,381	1,127
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]		34.2	8.11
Sr^{90}	7.70	7.18	6.84	7.96	9.13	5.77	4.30	2.80	2.58	3.50	6.95	11.28
Los Angeles												
K^{40}	1,220	1,260	1,360	1,430	1,564	1,379	1,358	2,051	1,390	1,375	1,386	1,252
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]			
Sr^{90}	2.09	2.09	0.92	1.40	1.22	1.24	1.02	2.36	1.22	1.78	1.41	1.88
Sacramento												
K^{40}	1,316	1,330	1,350	1,379	1,380	1,335	1,266	1,378	1,385	1,314	1,355	1,235
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]		21.2	
Sr^{90}	1.60	2.79	2.17	3.12	2.42	2.47	1.67	1.89	1.41	1.53	2.07	3.78
San Diego												
K^{40}	1,318	1,280	1,360	1,352	1,370	1,332	1,277	1,318	1,385	1,323	1,315	1,217
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]			
Sr^{90}	1.44	1.41	1.70	1.08	1.62	1.26	0.67	2.57	0.74	0.83	1.64	2.80
Santa Clara												
K^{40}	1,178	1,370	1,350	1,358	1,330	1,354	1,205	1,349	1,336	1,328	1,335	1,266
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]			
Sr^{90}	1.25	0.83	1.02	1.91	1.64	1.22	1.81	3.53	1.75	1.42	2.07	2.07
Shasta												
K^{40}	1,301	1,370	1,280	1,267	1,400	1,264	1,165	1,273	1,365	1,327	1,315	1,243
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]			
Sr^{90}	2.52	2.69	3.35	2.95	4.03	3.60	2.22	1.50	2.02	2.68	2.67	3.32
Sonoma												
K^{40}	1,170	1,350	1,217	1,286	1,310	1,343	1,294	1,278	1,350	1,295	1,334	1,239
Cs^{137}	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]			
Sr^{90}	2.94	3.13	3.68	3.65	3.97	2.34	1.86	3.92	1.77	2.35	3.74	3.65

[a] Except during October–December 1961, a sample of milk for potassium-40 and cesium-137 analyses, or a composite sample for strontium-90 analysis, was taken from a milk distribution center in each sampling area every month.

[b] A blank space indicates no sample.

[c] No significant activity.

TABLE 3.—STRONTIUM-89 AND STRONTIUM-90 IN CALIFORNIA MILK, FIRST HALF 1962

Sampling areas	Strontium-89 (μμc/g Calcium)						Strontium-90 (μμc/g Calcium)					
	Jan	Feb	Mar	Apr	May	Jun	Jan	Feb	Mar	Apr	May	Jun
Alameda	5.9	7.6	31.8	20.3	16.2	18.3	1.7	2.3	2.9	2.7	3.0	3.6
Del Norte	[a]		307	358	27.1	80.7			16.8	30.9	34.7	19.0
Fresno	5.3	4.5	8.7	16.9	13.9	12.0	1.3	1.3	1.2	2.4	2.6	3.5
Humboldt	154	165	216	111	65.8	27.2	7.5	8.5	11.8	8.3	9.1	5.5
Los Angeles	6.4	4.8	12.2	10.8	9.5	10.8	1.6	1.3	1.9	1.7	2.1	1.6
Mendocino			8.6	37.7	33.5	15.7			1.3	5.0	5.3	3.4
Sacramento	7.5	8.8	33.8	34.6	28.1	19.6	2.1	1.6	4.5	3.4	4.1	3.5
San Diego	7.4	5.0	20.9	29.9	12.3	11.1	1.5	1.1	1.6	3.3	2.7	2.0
Santa Clara	5.9	5.3	17.0	18.5	19.3	13.2	1.7	1.4	2.2	2.4	3.1	2.3
Shasta	8.3	10.4	25.5	52.0	43.7	29.0	2.3	2.1	3.5	4.0	6.3	5.3
Sonoma	15.6	49.0	75.9	55.1	37.4	20.5	2.2	3.2	5.5	5.8	5.4	4.9

[a] A blank space indicates that no specific determination was made.

is coupled to a 2-inch pyrex 10-stage photomultiplier tube and mounted within a commercial lead pig.

The 3″ x 3″ sodium iodide crystal is also coupled to a pyrex 10-stage photomultiplier tube housed in a 2-inch lead pig, which is shielded by 4-inch lead bricks. The high voltage power supply is a battery pack for voltage stability and interference elimination.

The 4″ x 4″ sodium iodide crystal is optically coupled to a quartz 11-stage 3-inch photomultiplier tube. This crystal has a resolution of 9 percent for a cesium–137 source. The detector unit is housed in a 6-ton steel chamber which provides 6 inches of steel, $\frac{1}{8}$ inch of lead, $\frac{1}{8}$ inch of cadmium, and $\frac{1}{16}$ inch of copper shielding. The layer of high-Z lead reduces backscatter from the steel, and the successively lower-Z cadmium and copper reduce, in turn, the 75-Kev lead flourescence X-rays. In whole milk samples, the counting efficiency for iodine-131 is 4.0 percent.

INDIANA MILK NETWORK
October–November 1962

Bureau of Environmental Sanitation
Indiana State Board of Health

In September 1961, the Indiana State Board of Health initiated a program of milk sampling for radiological analyses. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 6).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium-lanthanum–140, strontium–89, and strontium–90. Analyses for iodine–131, cesium–137, and barium-lanthanum–140 are conducted on a weekly basis except when iodine–131 results exceed 100 μμc/liter, at which time the frequency of sampling is increased. Samples which are analyzed for strontium–90 are composited weekly and analyzed monthly.

The trichloroacetic acid analytical procedure (*1*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4″ x 4″ sodium iodide crystal are used for the gamma scintillation analysis of iodine–131, cesium–137, and barium-lanthanum–140.

FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Robert A. Taft Sanitary Engineering Center, Public Health Service: *Radionuclide Analysis of Environmental Samples, Technical Report, R59–6* (1959).

TABLE 4.—INDIANA MILK NETWORK, OCTOBER–NOVEMBER 1962

[Concentrations in μμc/liter]

Sampling location	Strontium–89		Strontium–90		Iodine–131		Cesum–137		Barium–140	
	October	November	October	November	October	November	October	November	October	November
Evansville	95	[a]	14	[a]	80	110	35	40	10	10
Fort Wayne	60	[a]	19	[a]	70	40	45	50	<10	<10
Indianapolis	80	[a]	5	[a]	40	100	40	45	10	<10
Rochester	85	[a]	13	[a]	70	60	50	50	<10	<10
Seymour	100	[a]	4	[a]	40	80	40	50	<10	<10
State average	85	[a]	11	[a]	60	80	40	45	<10	<10

[a] Available next month.

RADIONUCLIDES IN CANADIAN MILK
Third Quarter 1962

Radiation Protection Division,
Department of National Health and Welfare,
Ottawa, Canada

Both dried milk products (skim milk and buttermilk powder) and liquid whole milk are currently being sampled by the Department of National Health and Welfare.

Dried Milk Products

Samples are collected through the cooperation of the Marketing Division of the Canadian Department of Agriculture, whose dairy products inspectors pick up four 1-pound samples of dried milk from each station (see figure 7) on a monthly schedule.

FIGURE 7.—CANADIAN DRIED MILK SAMPLING STATIONS

No statistical plan is followed for sample collection. Because of uncertainties introduced by this method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. However, it is possible to consider all results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figures 8, 9 and 10. It should be emphasized that average concentrations over a considerable period of time are more meaningful from the public health point of view than fluctuating monthly concentrations.

A detailed discussion of the sampling and

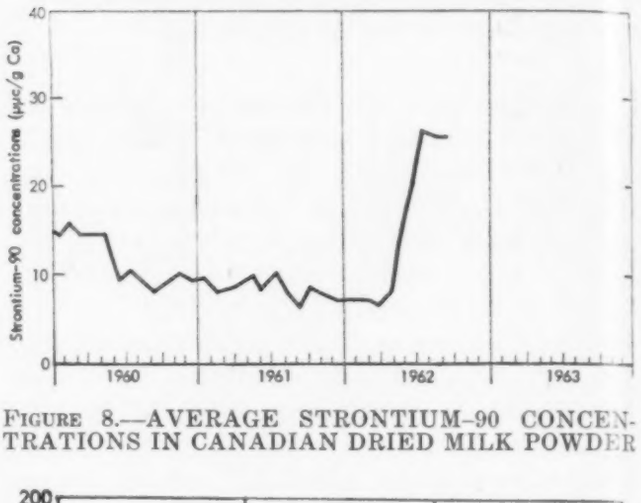

FIGURE 8.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

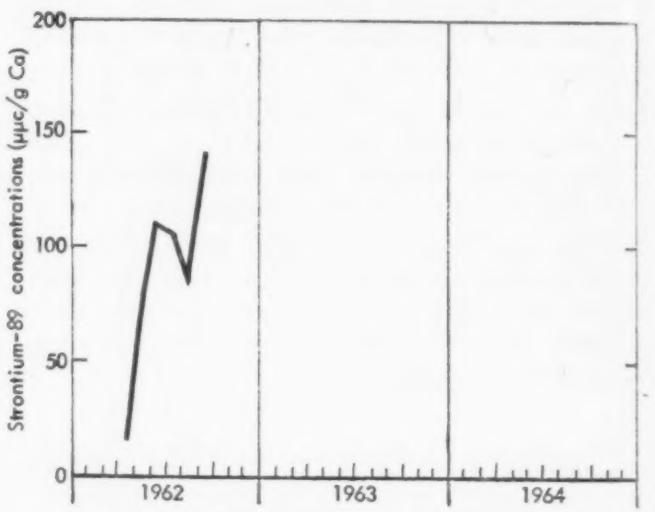

FIGURE 9.—AVERAGE STRONTIUM-89 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

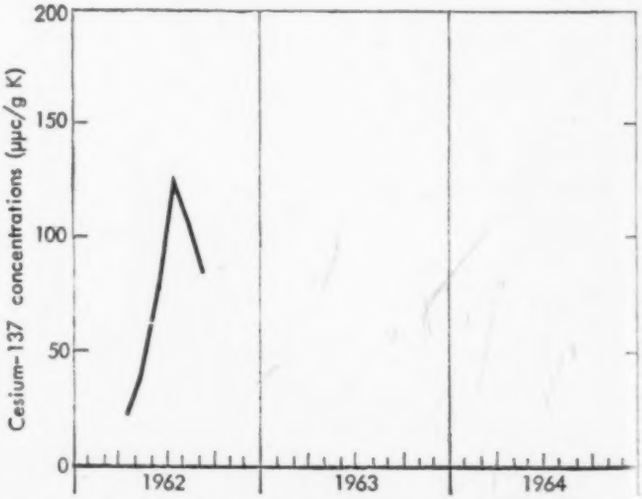

FIGURE 10.—AVERAGE CESIUM-137 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

TABLE 5.—RADIONUCLIDES IN CANADIAN DRIED MILK POWDER, 1962

Station	Strontium–89 μμc/g Ca			Strontium–90 μμc/g Ca			Cesium–137 μμc/g K		
	July	Aug.	Sep.	July	Aug.	Sep.	July	Aug.	Sep.
Arborg [a]	90.3	106.1	116.7	20.5	41.6	20.8	88.9	75.6	69.6
Calgary [a]	165.0	47.1	287.0	34.5	16.2	39.3	128.8	129.8	102.3
E. Florenceville [a]	126.0	97.0	178.6	27.3	31.2	34.5	107.1	111.3	124.3
Edmonton	136.2	83.0	389.4	24.7	25.0	42.3	93.3	71.6	107.0
Granthal	74.4	95.4	119.9	19.3	28.4	19.7	[b]—	85.6	79.5
Halifax	104.2	171.5	163.3	32.9	29.9	27.7	161.1	135.2	95.1
La Durantaye	107.6	80.9	115.9	26.0	35.8	21.7	135.6	121.2	68.6
Lawrenceville	99.7	106.8	95.8	32.9	42.1	28.3	160.6	168.2	82.4
London	63.8	45.2	57.3	11.4	11.7	21.7	77.4	53.0	34.8
Megantic	85.0	113.4	141.7	29.2	31.3	34.7	183.7	212.6	113.6
Moncton	236.9	126.3	108.1	51.8	31.5	21.4	189.5	131.5	85.7
Nicolet	116.3	62.9	104.4	29.0	18.7	21.1	—	69.5	67.7
Ottawa	54.1	47.3	45.7	12.8	13.9	13.0	57.1	65.0	57.8
Saskatoon [a]	61.8	47.9	170.5	12.6	13.3	22.1	—	59.8	58.8
Sussex	176.5	99.5	136.2	44.7	36.7	36.1	141.2	119.3	104.7
Vancouver	105.7	46.3	108.6	27.6	23.5	21.1	155.2	130.9	112.8
Walkerton	75.8	49.1	72.1	14.1	11.6	15.9	71.0	70.0	59.8
Average	110.5	83.9	141.8	26.5	26.0	25.9	125.0	106.5	83.8

[a] Buttermilk—all other samples were skim milk powders.
[b] Dash indicates no sample.

radiochemical procedures employed may be found in the Department's publication (*1*). Table 5 presents the results of measurements of strontium–89, strontium–90 and cesium–137 in Canadian dried milk powder for the third quarter of 1962. These data were taken from the "Monthly Report, Radioactive Fallout in Canada," dated October–November 1962, published by the Radiation Protection Division of the Department of National Health and Welfare.

The average strontium–90 concentrations in milk remained approximately constant at about 26 μμc/g calcium during the third quarter of 1962. The Canadian average for the twelve-month period from October 1961 through September 1962 was 13.9 μμc Sr^{90}/g calcium, and the record high of 26.5 μμc Sr^{90}/g calcium occurred in July 1962.

The average strontium–89 concentration in milk increased markedly during the second quarter 1962, and have fluctuated during the third quarter.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g calcium to other milk data in units of μμc/liter, it can be assumed that milk has approximately 1.2 g calcium/liter of liquid milk. Canadian powdered milk data may be compared to liquid milk data by multiplying the former values by 1.2.

The average cesium–137 concentrations in dried milk rose from 20.3 μμc/g potassium in April to 125.0 μμc/g potassium in July and then declined to 83.8 μμc/g potassium in September.*

Whole Milk

Recently, monitoring of liquid whole milk for iodine–131 was begun. The presence of iodine–131 in milk is closely dependent on the continuance of nuclear testing programs because of the short half-life (8 days) of iodine–131. Iodine levels will decrease quickly in the absence of such testing. Iodine–131 levels in milk are also expected to fall rapidly when dairy cows are taken off pasture for the winter.

Table 6 presents the average monthly concentration of iodine–131 in liquid whole milk for seven cities for May through September 1962. The average rose sharply from 8.4 μμc/liter in August to 138 μμc/liter in September.

TABLE 6.—IODINE–131 IN CANADIAN LIQUID WHOLE MILK, 1962

[Concentrations in μμc/liter]

Station	May	June	July	August	September
Calgary	—	—	13.4	10.8	372
Halifax	13.0	6.9	7.3	8.0	44
London	—	—	14.1	6.6	110
Ottawa	6.6	5.0	9.3	4.9	76
Sault St. Marie	—	—	—	10.6	172
Winnipeg	—	—	5.8	6.7	140
Vancouver	5.9	6.1	3.9	10.9	50
Average	8.5	6.0	9.0	8.4	138

It should be emphasized again that the in-

* April data taken from January 1963 *Radiological Health Data.*

terpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC), as established by the International Commission on Radiological Protection (*2*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

Previous coverage in *Radiological Health Data:*

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second quarter 1962	*January 1963*

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW (RP–1)* (July 1958).

(*2*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation, Pergamon Press, New York,* (1959).

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

December 1961–November 1962: Iodine–131
November 1961–October 1962: Strontium–89 and Strontium–90

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council is given in terms of ranges of transient rates of intake of radioactive materials in micromicrocuries per day. These ranges are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations. The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and has recently emphasized that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

Tables 1 and 2 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine–131, strontium–89, and strontium–90 and facilitate comparison of the concentrations of certain radionuclides in milk with the FRC's Radiation Protection Guides. The tables are based on the same data which are used for computing the Pasteurized Milk Network monthly averages. They present index values which are the estimated sum of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium–89 and strontium–90 analysis, these 12-month index values are for the year beginning one month earlier than the year for the iodine–131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the first column in table 1 gives the iodine–131 November concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. Procedures exemplified by (a) and (b) above minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine–131.

For a number of reasons it is desirable to have a standard quantity of milk to use in the

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

Sampling locations		Nov 1962 Iodine-131 averages ($\mu\mu$c/liter)	Iodine-131 index values ($\mu\mu$c day/liter)[a]			
			Nov 1961-Oct 1962	Nov 1961	Oct 28, 1962-Nov 24, 1962	Dec 1961-Nov 1962
Ala:	Montgomery	70	3,800	900	1,960	4,860
Alaska:	Palmer	40	36,990	1,200	1,120	36,910
Ariz:	Phoenix	30	5,430	2,400	840	3,870
Ark:	Little Rock	100	9,640	4,500	2,800	7,940
Calif:	Sacramento	20	4,300	900	560	3,960
	San Francisco	10	4,350	600	280	4,030
Colo:	Denver	20	6,340	1,200	560	5,700
Conn:	Hartford	50	6,980	900	1,400	7,480
Del:	Wilmington	140	8,370	1,800	3,920	10,490
D.C:	Washington	80	6,360	900	2,240	7,700
Fla:	Tampa	80	3,650	1,200	2,240	4,690
Ga:	Atlanta	80	5,220	1,200	2,240	6,260
Hawaii	Honolulu	20	3,710	600	560	3,670
Idaho	Idaho Falls	50	10,450	3,000	1,400	8,850
Ill:	Chicago	60	13,570	2,100	1,680	13,150
Ind:	Indianapolis	90	9,710	1,800	2,520	10,430
Iowa:	Des Moines	120	22,620	6,300	3,360	19,680
Kans:	Wichita	80	21,540	4,200	2,240	19,580
Ky:	Louisville	130	7,820	2,400	3,640	9,060
La:	New Orleans	60	5,680	1,800	1,680	5,560
Maine:	Portland	70	6,770	900	1,960	7,830
Md:	Baltimore	80	6,610	900	2,240	7,950
Mass:	Boston	40	7,990	1,200	1,120	7,910
Mich:	Detroit	80	12,600	2,700	2,240	12,140
	Grand Rapids	50	9,140	1,800	1,400	8,740
Minn:	Minneapolis	80	17,620	4,500	2,240	15,360
Miss:	Jackson	80	6,020	1,800	2,240	6,460
Mo:	Kansas City	140	28,840	5,700	3,920	27,060
	St. Louis	80	12,130	3,000	2,240	11,370
Mont:	Helena	70	13,300	3,300	1,960	11,960
Nebr:	Omaha	80	17,510	3,600	2,240	16,150
Nev:	Las Vegas[b]	10	3,500	[c]—	280	3,780
N.H:	Manchester	40	7,180	1,200	1,120	7,100
N.J:	Trenton	90	5,830	900	2,520	7,450
N. Mex:	Albuquerque	20	6,850	1,200	560	6,210
N.Y:	Buffalo	20	8,570	600	560	8,530
	New York	80	10,080	1,200	2,240	11,120
	Syracuse	40	9,570	900	1,120	9,790
N.C:	Charlotte	30	2,590	600	840	2,830
N.D:	Minot	60	13,500	600	1,680	14,580
Ohio:	Cincinnati	140	11,320	2,400	3,920	12,840
	Cleveland	80	9,120	1,500	2,240	9,860
Okla:	Oklahoma City	100	15,180	4,800	2,800	13,180
Ore:	Portland	80	11,050	5,100	2,240	8,190
Pa:	Philadelphia	130	7,350	1,200	3,640	9,790
	Pittsburgh	170	9,220	900	4,760	13,080
P.R:	San Juan	[d]	3,990	600	—	3,390
R.I:	Providence	80	7,160	1,500	2,240	7,900
S.C:	Charleston	40	3,510	600	1,120	4,030
S.D:	Rapid City[e]	90	10,190	—	2,520	12,710
Tenn:	Chattanooga	90	5,010	1,200	2,520	6,330
	Memphis	100	6,970	2,400	2,800	7,370
Tex:	Austin	60	4,080	1,800	1,680	3,960
	Dallas	80	7,240	3,000	2,240	6,480
Utah:	Salt Lake City	30	32,200	1,800	840	31,240
Vt:	Burlington	70	7,900	1,500	1,960	8,360
Va:	Norfolk	60	4,540	900	1,680	5,320
Wash:	Seattle	90	9,990	3,600	2,520	8,910
	Spokane	40	21,490	1,800	1,120	20,810
W. Va:	Charleston	70	4,930	600	1,960	6,290
Wis:	Milwaukee	100	13,380	2,400	2,800	13,780
Wyo:	Laramie	10	20,590	900	280	19,970

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual I^{131} intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index (μμc day/liter) × milk consumption factor (liter/day/person) = 12-month I^{131} intake (μμc/person)

[b] Station began operation in July 1962.

[c] Dash indicates no data available.

[d] No sample was received for November 1962.

[e] Station began operation in January 1962.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values ($\mu\mu$c day/liter)[a]				Strontium-90 index values ($\mu\mu$c day/liter)[a]			
		Oct 1961–Sep 1962	Oct 1961	Sep 30, 1962–Oct 27, 1962	Nov 1961–Oct 1962	Oct 1961–Sep 1962	Oct 1961	Sep 30, 1962–Oct 27, 1962	Nov 1961–Oct 1962
Ala:	Montgomery	18,765	465	560	18,860	4,507	217	364	4,654
Alaska:	Palmer	16,900	3,255	4,200	17,845	3,513	496	448	3,465
Ariz:	Phoenix	5,190	80	1,400	6,510	1,242	93	196	1,345
Ark:	Little Rock	43,145	1,085	1,960	44,020	9,355	465	784	9,674
Calif:	Sacramento	6,015	310	420	6,125	1,460	248	112	1,324
	San Francisco	10,520	80	140	10,580	1,829	93	56	1,792
Colo:	Denver	10,640	465	560	10,735	3,109	186	364	3,287
Conn:	Hartford	6,940	930	1,400	7,410	3,655	310	336	3,681
Del:	Wilmington	13,140	1,395	1,400	13,145	4,409	465	392	4,336
D.C:	Washington	12,080	1,085	1,400	12,395	4,357	248	504	4,613
Fla:	Tampa	7,855	465	560	7,950	3,101	155	252	3,198
Ga:	Atlanta	27,815	620	840	28,035	5,926	372	504	6,058
Hawaii:	Honolulu	9,120	80	420	9,460	1,809	124	224	1,909
Idaho:	Idaho Falls	8,955	1,085	840	8,710	2,594	248	364	2,710
Ill:	Chicago	11,540	1,705	1,680	11,515	3,491	279	392	3,604
Ind:	Indianapolis	12,635	930	1,820	13,525	4,435	217	392	4,610
Iowa:	Des Moines	22,810	2,015	2,940	23,735	4,258	465	448	4,241
Kans:	Wichita	16,910	930	1,680	17,660	3,790	341	364	3,813
Ky:	Louisville	23,075	465	1,820	24,430	5,910	341	672	6,241
La:	New Orleans	65,530	1,240	1,260	65,550	10,054	465	672	10,261
Maine:	Portland	11,955	3,720	2,100	10,335	4,484	341	532	4,675
Md:	Baltimore	11,165	930	1,400	11,635	4,535	248	504	4,791
Mass:	Boston	12,785	3,720	2,800	11,865	5,029	372	560	5,217
Mich:	Detroit	9,585	1,550	1,960	9,995	3,204	217	448	3,435
	Grand Rapids	10,935	2,325	1,260	9,870	3,161	217	308	3,252
Minn:	Minneapolis	24,030	5,270	3,360	22,120	4,862	527	728	5,063
Miss:	Jackson	55,910	1,240	1,120	55,790	8,323	372	588	8,539
Mo:	Kansas City	28,390	2,635	2,800	28,555	4,503	217	476	4,762
	St. Louis	17,355	930	1,540	17,965	4,427	310	448	4,565
Mont:	Helena	13,510	465	1,540	14,585	3,428	403	532	3,557
Nebr:	Omaha	24,255	3,875	1,960	22,340	4,156	465	364	4,055
Nev:	Las Vegas[b]	2,345	[c]—	700	3,045	427	—	224	651
N.H:	Manchester	9,385	1,240	2,240	10,385	4,501	372	644	4,773
N.J:	Trenton	8,885	1,240	1,820	9,465	3,658	248	392	3,802
N. Mex:	Albuquerque	4,675	80	420	5,015	1,645	310	168	1,503
N.Y:	Buffalo	8,795	1,395	1,820	9,220	3,740	341	392	3,791
	New York	9,440	1,550	2,380	10,270	4,241	248	644	4,637
	Syracuse	10,370	2,790	2,100	9,680	3,366	248	532	3,650
N.C:	Charlotte	18,445	930	1,400	18,915	6,122	279	588	6,431
N. Dak:	Minot	16,680	1,690	2,660	17,650	5,211	372	644	5,483
Ohio:	Cincinnati	16,690	775	1,400	17,315	4,487	186	476	4,777
	Cleveland	9,625	1,240	1,820	10,205	3,646	217	420	3,849
Okla:	Oklahoma City	24,850	930	1,120	25,040	5,113	186	476	5,403
Ore:	Portland	21,950	80	3,080	24,950	4,727	372	560	4,915
Pa:	Philadelphia	9,110	1,085	1,260	9,285	4,004	217	420	4,207
	Pittsburgh	10,845	2,015	1,680	10,510	4,741	279	644	5,106
P.R:	San Juan	23,900	310	560	24,150	3,200	217	196	3,179
R.I:	Providence	10,260	1,860	1,680	10,080	3,929	310	532	4,151
S.C:	Charleston	21,200	465	980	21,715	6,034	341	532	6,225
S. Dak:	Rapid City[d]	15,480	—	1,680	17,160	4,082	—	392	4,474
Tenn:	Chattanooga	38,255	775	1,260	38,740	7,107	310	560	7,357
	Memphis	35,930	930	1,680	36,680	6,748	217	532	7,063
Tex:	Austin	9,555	310	280	9,525	2,218	124	196	2,290
	Dallas	22,920	620	700	23,000	4,596	248	476	4,824
Utah:	Salt Lake City	10,080	775	840	10,145	2,692	217	280	2,755
Vt:	Burlington	9,575	1,550	2,520	10,545	3,702	248	392	3,846
Va:	Norfolk	18,560	2,635	1,120	17,045	5,472	248	560	5,784
Wash:	Seattle	18,235	2,325	2,940	18,850	4,792	465	812	5,139
	Spokane	10,555	310	1,120	11,365	3,629	186	420	3,863
W. Va:	Charleston	20,530	2,170	1,820	20,180	5,555	248	762	5,979
Wis:	Milwaukee	7,670	1,240	1,680	8,110	2,713	279	336	2,770
Wyo:	Laramie	14,850	80	1,680	16,450	3,011	248	364	3,127

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 and strontium-90 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month Sr^{89} or Sr^{90} index (μμc day/liter) × milk consumption factor (liter/day/person) = 12-month Sr^{89} or Sr^{90} intake (μμc/person)

[b] Station began operation in July 1962.

[c] Dash indicates no data are available.

[d] Station began operation in January 1962.

evelopment of index values for the different adionuclides. In the case of strontium, 1 liter is a suitable quantity as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. In the case of iodine–131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18 month group is not more than 1 liter per day. Thus the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

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(*1*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159–65 (May 1962).

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SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
August 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network was initiated in October 1957. (*1*). This network, operated by the Public Health Service in cooperation with State and local agencies, consisted of 123 stations as of the end of August (figure 1).

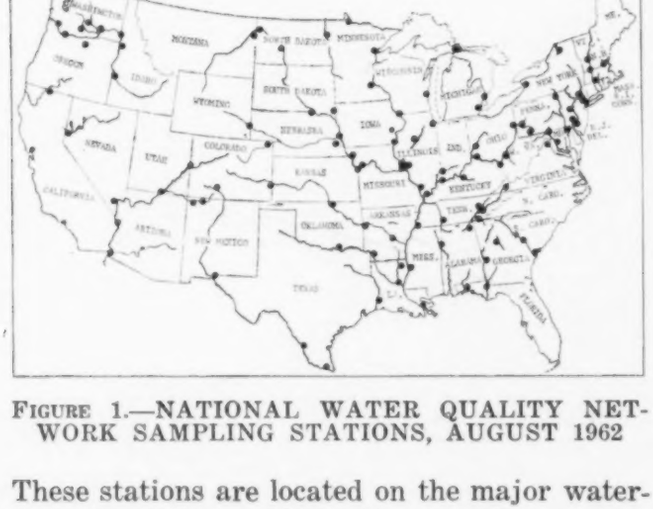

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, AUGUST 1962

These stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. Samples are taken weekly, monthly, or continuously, depending on the type of analysis and the water quality. These samples are analyzed for plankton population, organic chemicals, chemical, biological, and physical quality, and radioactivity (*2*, *3*).

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*4*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples according to established procedures (*5*, *6*). Because strontium–90 analyses are done quarterly, the results will be published on this basis.

For the first two years, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, AUGUST 1962

[Average concentrations in pc/liter]

Station	August 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	6	19	25	0	0	0
Animas River: Cedar Hill, N. Mex	9	26	35	1	5	6
Apalachicola River: Chattahoochie, Fla	2	8	10	0	0	0
Arkansas River:						
Coolidge, Kans	54	124	178	6	17	23
Ponca City, Okla	115	37	152	19	1	20
Pendleton Ferry, Ark	—	—	—	—	—	—
Bear River: Preston, Idaho	6	29	35	0	1	1
Bighorn River: Hardin, Mont	322	54	376	50	6	56
Big Sioux River: Sioux Falls, S. Dak	17	48	65	1	4	5
Chattahoochie River:						
Atlanta, Ga	7	6	13	1	0	1
Columbus, Ga	5	9	14	—	—	—
Lanett, Ala	7	10	17	1	0	1
Chena Slough: Fairbanks, Alaska	5	11	16	0	<1	<1
Clear Water River: East Lewiston, Idaho	7	5	12	0	0	0
Clinch River: Kingston, Tenn	136	58	195	5	<1	5
Colorado River:						
Loma, Colo	17	29	46	2	8	10
Page, Ariz	206	26	232	43	6	49
Boulder City, Nev	22	37	59	0	5	5
Parker Dam, Calif.-Ariz	13	21	34	1	10	11
Yuma, Ariz	39	80	119	1	0	1
Columbia River:						
Northport, Wash	5	10	15	0	1	1
Wenatchee, Wash	5	15	20	0	0	0
Pasco, Wash	37	336	373	0	0	0
McNary Dam, Ore	26	180	206	0	0	0
Bonneville, Ore	—	—	—	—	—	—
Clatskanie, Ore	19	129	148	0	0	0
Connecticut River:						
Wilder, Vt	7	16	23	0	0	0
Northfield, Mass	4	13	17	—	—	—
Enfield Dam, Conn	7	11	18	0	0	0
Cumberland River: Clarksville, Tenn	—	—	—	—	—	—
Delaware River:						
Martins Creek, Pa	2	8	10	0	0	0
Trenton, N.J	2	9	11	0	<1	<1
Philadelphia, Pa	9	13	22	—	—	—
Escambia River: Century, Fla	15	12	27	0	0	0
Great Lakes:						
Duluth, Minn	6	6	12	0	0	0
Sault Ste. Marie, Mich	2	10	12	—	—	—
Milwaukee, Wis	3	11	14	0	0	0
Gary, Ind	4	10	14	0	0	0
Port Huron, Mich	4	11	15	—	—	—
Detroit, Mich	2	6	8	0	1	1
Buffalo, N.Y	24	10	34	0	0	0
Green River: Dutch John, Utah	10	23	33	1	2	3
Hudson River: Poughkeepsie, N.Y	3	10	13	0	0	0
Illinois River:						
Peoria, Ill	8	26	34	0	0	0
Grafton, Ill	6	30	36	1	1	2
Kanawha River: Winfield Dam, W. Va	9	10	19	—	—	—
Klamath River: Keno, Ore	5	11	16	0	0	0
Little Miami River: Cincinnati, Ohio	6	14	20	—	—	—
Mississippi River:						
St. Paul, Minn	20	28	48	0	2	2
Dubuque, Iowa	—	—	—	—	—	—
Burlington, Iowa	6	22	28	0	0	0
E. St. Louis, Ill	6	28	34	—	—	—
Cape Girardeau, Mo	46	32	78	3	2	5
W. Memphis, Ark	26	24	50	0	1	1
Delta, La	43	30	73	21	2	23
New Orleans, La	8	22	30	0	1	1
Vicksburg, Miss	33	29	62	4	1	5
Missouri River:						
Williston, N. Dak	73	31	104	—	—	—
Bismarck, N. Dak	14	24	38	<1	3	3
Yankton, S. Dak	34	45	79	0	3	3
Omaha, Nebr	55	41	96	4	6	10
St. Joseph, Mo	69	60	129	—	—	—
Kansas City, Kans	55	41	96	4	4	8
St. Louis, Mo	146	39	185	6	8	14
Missouri City, Mo	53	31	84	1	4	5
Monongahela River: Pittsburgh, Pa	1	22	23	—	—	—
North Platte River: Henry, Nebr	25	46	71	1	9	10
Ohio River:						
Addison, Ohio	12	8	20	0	0	0
Huntington, W. Va	1	9	10	0	0	0
Cincinnati, Ohio	2	18	20	0	0	0
Louisville, Ky	5	15	20	0	0	0
Evansville, Ind	11	22	33	0	0	0
Cairo, Ill	8	15	23	0	0	0
Ouachita River: Bastrop, La	5	12	16	1	1	2
Pend Oreille River: Albeni Falls Dam, Idaho	2	9	11	0	0	0
Platte River: Plattsmouth, Nebr	118	57	175	7	2	9

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, AUGUST 1962—Continued

[Average concentrations in pc/liter]

Station	August 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Potomac River:						
Williamsport, Md	1	10	11	—	—	—
Great Falls, Md	1	16	17	1	0	1
Rainy River:						
Baudette, Minn	12	38	50	0	0	0
International Fls., Minn	7	30	37	0	0	0
Raritan River: Perth Amboy, N.J	36	129	165	3	0	3
Red River, North: Grand Forks, N. Dak	—	—	—	—	—	—
Red River, South:						
Denison, Tex	30	108	138	1	3	4
Index, Ark	4	10	14	0	1	1
Bossier City, La	23	74	97	1	1	2
Alexandria, La	7	67	74	1	1	2
Rio Grande River:						
Alamosa, Colo	1	11	12	0	4	4
El Paso, Tex	46	22	68	2	3	5
Laredo, Tex	35	25	60	1	6	7
Brownsville, Tex	16	52	68	0	2	2
Roanoke River: John H. Kerr Resr. & Dam, Va	5	7	12	1	0	1
Sabine River: Ruliff, Tex	7	14	21	0	1	1
Sacramento River: Greens Landing Courtland, Calif	3	9	12	0	0	0
San Joaquin River: Vernalis, Calif	9	27	36	<1	6	6
San Juan River: Shiprock, N. Mex	5	73	78	0	19	19
St Lawrence River: Massena, N.Y	5	7	12	0	0	0
Schuykill River: Philadelphia, Pa	4	23	27	0	0	0
Savannah River:						
North Augusta, S.C	6	5	11	0	0	0
Port Wentworth, Ga	7	90	97	0	0	0
Shenandoah River: Berryville, Va	17	12	29	1	1	2
Ship Creek: Anchorage, Alaska	3	6	9	0	0	0
Snake River:						
Ice Harbor Dam, Wash	2	10	12	0	1	1
Wawawai, Wash	3	17	20	0	2	2
Payette, Idaho	8	15	23	1	3	4
South Platte River: Julesburg, Colo	43	88	131	4	21	25
Spokane River: Post Falls, Idaho	3	8	11	0	0	0
Susquehanna River:						
Sayre, Pa	5	16	21	0	0	0
Conowingo, Md	3	12	15	0	0	0
Tennessee River:						
Chattanooga, Tenn	3	31	34	0	0	0
Bridgeport, Ala	5	40	45	0	0	0
Pickwick Landing, Tenn	9	15	24	1	0	1
Lenoir City, Tenn	3	9	12	0	0	0
Tombigbee River: Columbus, Miss	8	9	17	1	0	1
Truckee River: Farad, Calif	1	4	5	0	1	1
Verdigris River: Nowata, Okla	4	34	38	<1	<1	1
Wabash River: New Harmony, Ind	45	19	64	3	<1	3
Willamette River: Portland, Ore	2	2	4	0	0	0
Yakima River: Richland, Wash	4	12	16	0	1	1
Yellowstone River: Sidney, Mont	165	31	196	5	4	9

beta determinations were generally made once a month on weekly composited samples. Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analysis are done weekly.

If at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least one every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium–90 (*7*). Strontium–90 data will be presented quarterly.

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for August 1962. Figure 2 shows the median of the quarterly averages of each station of beta activity found in suspended plus dissolved solids of raw surface water for the years 1958 through 1961.

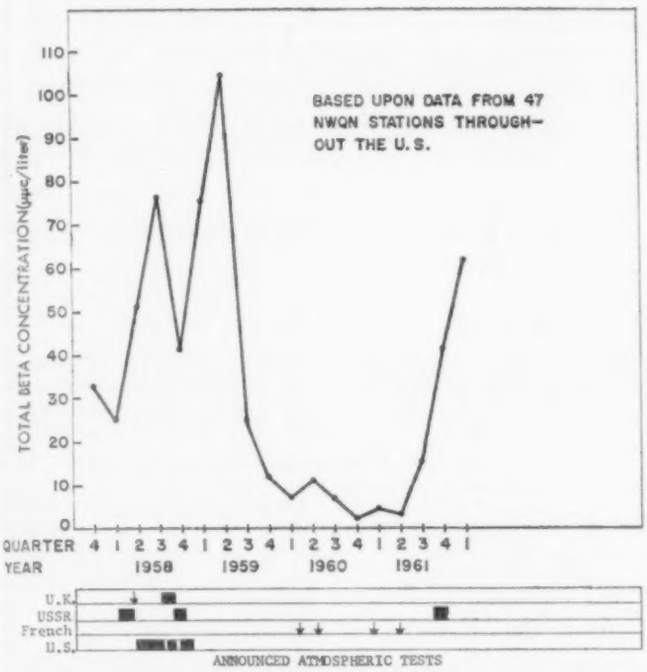

FIGURE 2.—MEDIAN TOTAL BETA RADIOACTIVITY IN U.S. RAW SURFACE WATER

REFERENCES

(*1*) Public Health Service: National Water Quality Control Network, *Fallout From Nuclear Weapons Tests*, *1*:167–9, Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 1959), price $2.75.

(*2*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1960 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

(*3*) Setter, L. R., and S. L. Baker: Radioactivity of Surface Waters in the United States, *Radiological Health Data*, *1*:20–31 (October 1960).

(*4*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association*, *53*:704 (June 1961).

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(*6*) Robert A. Taft Sanitary Engineering Center, Public Health Service: *Radionuclide Analysis of Environmental Samples, Technical Report, R59–6* (1959).

(*7*) Straub, C. P., L. R. Setter, A. Goldin, and P. F. Hallbach: Strontium–90 in Surface Waters in the U.S., *Journal of the American Water Works Association*, *52*:756 (June 1960).

North Carolina Cistern Water

June and August 1962

Sanitary Engineering Division
North Carolina State Board of Health

Investigations of radioactivity in North Carolina public surface water supplies have been underway since June 1958 (*1*). Originally, these studies were confined to surface water supplies, but during 1962 they were extended to include several small cistern water supplies utilized for drinking water on islands situated along the eastern seaboard.

The cistern supplies are characteristically constructed with roof pre-wash valves which permit the diversion of the first runoff and then allow the balance of the rainwater to pass into the cistern.

First available results from the cistern water sampling, begun in June 1962, have been received for ten cistern supplies on Ocracoke Island, which lies approximately 20 miles off the mainland (figure 3). Radioanalyses of the

samples are performed at the State Laboratory in Raleigh. A one liter sample is collected and the total solids content is analyzed for gross radioactivity (alpha plus beta).

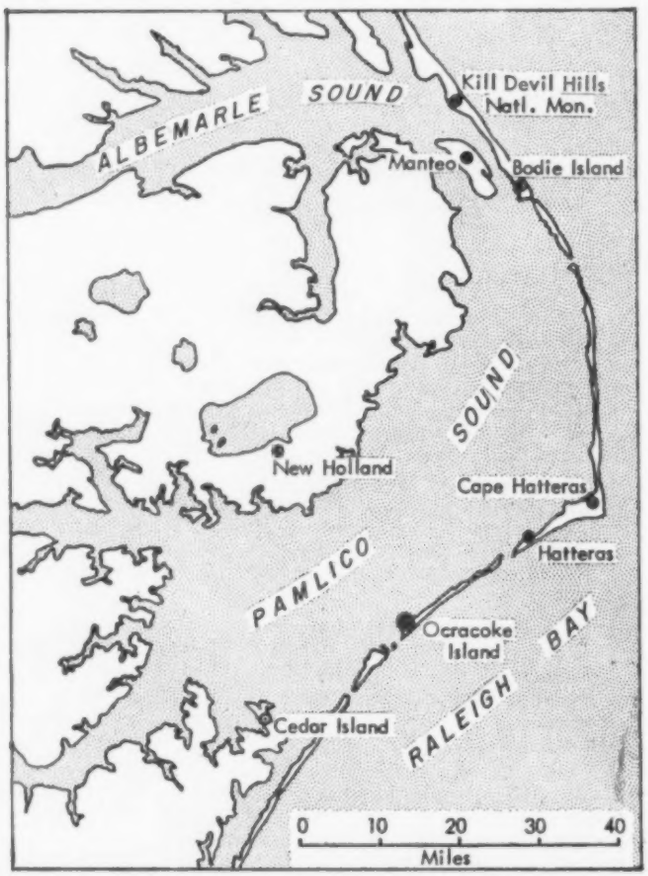

FIGURE 3.—EASTERN NORTH CAROLINA, SHOWING LOCATION OF OCRACOKE ISLAND

TABLE 2.—GROSS RADIOACTIVITY IN CISTERN WATER AT OCRACOKE ISLAND, NORTH CAROLINA

[μμc/liter]

Type of supply	June 20, 1962	August 29, 1962
Private residence	96	[a]—
Private residence	105	33
Private residence	71	—
Private residence	63	—
Public school	57	25
Public school	83	—
Hotel	75	—
Hotel	98	—
Public park	88	35
Coast Guard Station	190	61

[a] No sample

While the concentrations of strontium–90 and alpha emitters are not reported, some comparison may be drawn between the values shown in table 2 and drinking water standards for interstate carriers (*2*). These standards state that in the absence of strontium–90 and alpha emitters, a water supply is acceptable when the gross beta activity does not exceed 1000 μμc/liter.

REFERENCES

(*1*) Sanitary Engineering Division, North Carolina State Board of Health: *Background Radioactivity in Surface Water Supplies of North Carolina, 1958–1961.*

(*2*) Federal Register Rules and Regulations: *Title 42–Public Health Chapter 1–Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27*:2154–5, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (March 6, 1962).

SECTION V.—OTHER DATA

Cesium–137 and Strontium–90 in Animal Feeds
1959–1962

Division of Pharmacology, Food and Drug Administration

Recognizing the importance of animal feeds in the food chain, the Food and Drug Administration (FDA) regularly samples and analyzes these products for cesium–137 and strontium–90, using the same procedures previously discussed for the FDA human food sampling program (*1*). The results of FDA determinations of the cesium–137 and strontium–90 contents of some selected animal feeds, arranged by year of harvest, are presented in table 1. It should be noted that the number of samples analyzed for cesium–137 is small, and that the number of samples analyzed for strontium–90 is small for some products.

From the table an approximate correlation between cesium–137 and strontium–90 is noted, in that the cesium–137 concentration is higher than the strontium–90 concentration in all samples.

Alfalfa

The cesium–137 data are too few for proper analysis, but the high values in 1962 are of interest. It can be observed that the strontium–90 content of alfalfa, however, decreased from 1959 to 1960, and then increased in 1961 and 1962. Samples harvested before resumption of nuclear weapons testing in September 1961 are from different parts of the country than those harvested after the resumption of nuclear weapons testing in late 1961 and in 1962; therefore, the 1961 and 1962 values cannot be directly compared with each other.

Beet Pulp

Some slight increase in strontium–90 content from 1960 to 1961 is noted.

Corn Silage

The limited cesium–137 values show a decrease from 1960 to 1961, while the strontium–90 values decreased from 1959 to 1961. The one value for 1962 is inconclusive.

Cottonseed

The cesium–137 values show very little in the way of a definite trend, although a difference in values may be noted. Cottonseed meal increased in strontium–90 content from 1959 to 1961, while the values for cottonseed hulls show little definite trend.

Lespedeza

The strontium–90 values show a decrease from 1959 through 1960 and into 1961, with an apparent increase from 1961 to 1962.

Peanut Hay

Little difference in strontium–90 values for 1960 through 1962 can be seen.

TABLE 1.—GEOGRAPHICAL DISTRIBUTION OF CESIUM-137 AND STRONTIUM-90 IN SELECTED ANIMAL FEEDS

Product	Cesium-137			Strontium-90		
	Number of samples	Average (pc/kg)	Range (pc/kg)	Number of samples	Average (pc/kg)	Range (pc/kg)
Alfalfa						
1959				22	378	23–1,470
1960				14	153	18– 425
1961	1	279		12	273	52– 779
1962	3	2,890	1,440–6,410	3	262	77– 365
Beet pulp						
1960				7	50	3.8– 127
1961				10	62	24– 112
Corn silage						
1959				17	90	19– 482
1960	3	759	2.7–2,000			
1961	2	649	556– 741	11	76	9– 513
1962				1	44	
Cottonseed hulls						
1960				2	42	36– 48
1961				1	30	
Cottonseed meal						
1959				1	4.6	
1960	3	215	34– 531	2	7.6	3.1– 12
1961	1	332		5	52	2.9– 95
Grass						
1959				1	510	
1960	1	194		1	145	
Hay						
1959				4	390	73– 732
1960	1	[a]ND				
1961				1	297	
Lespedeza						
1959				6	987	617–1,700
1960				8	479	45– 960
1961				3	393	204– 529
1962				2	658	417– 899
Peanut hay						
1960				7	740	507– 931
1961				3	726	520– 845
1962				1	639	
Sorghum						
1959				2	87	38– 49
1960				1	34	
1961	1	1900		3	198	35– 513

TABLE 1.—GEOGRAPHICAL DISTRIBUTION OF CESIUM-137 AND STRONTIUM-90 IN SELECTED ANIMAL FEEDS—Continued

Product	Cesium-137			Strontium-90		
	Number of samples	Average (pc/kg)	Range (pc/kg)	Number of samples	Average (pc/kg)	Range (pc/kg)
Soybean						
1959				1	27	
1960	1	ND		1	17	
1961				2	41	25- 57
1962 (meal)	1	500				
Timothy hay						
1959				4	413	355-1170

[a] N.D. indicates cesium-137 not detectable.

Sorghum

An apparent increase from 1959 and 1960 is seen in the 1962 strontium-90 values. Of interest is the single high cesium-137 value for 1962.

Summary

Limited cesium-137 concentrations in animal feeds are presented, together with more extensive values for strontium-90 concentrations. The cesium-137 values are higher than the strontium-90 values in all cases. The hays and leafy animal feeds continue to show increased radionuclide content over animal fodders.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960	*December 1961*

REFERENCE

(1) Food and Drug Administration: Survey of Radioactivity in Food, *Radiological Health Data*, 3:476-81 (December 1962).

Air and Water Monitoring Near the Project Chariot Site
January–August 1962

Atomic Energy Commission

In May 1959 the U.S. Atomic Energy Commission approved a program of environmental studies to be conducted in conjunction with a proposed excavation project using nuclear explosives (Project Chariot, Plowshare Program) at the mouth of Ogotoruk Creek near Cape Thompson, Alaska. To date, no nuclear detonations have been scheduled for the project. In August 1962, the Commission decided to defer a recommendation that the President authorize performance of the experiment.

The proposed project would involve the simultaneous detonation of five nuclear devices. Four 20-kiloton devices would be buried to about 400 feet and one 200-kiloton device buried to about 800 feet. The detonation of the four smaller devices would be expected to produce a channel about 900 feet wide and 2,000 feet long, with a basin about 1800 feet in diameter resulting from explosion of the larger device. It is expected that about 95 percent of the fission products will be entrapped underground.

After the U.S.S.R. resumed testing on September 1, 1961, four fallout monitoring stations were activated at Cape Thompson, Kivalina,

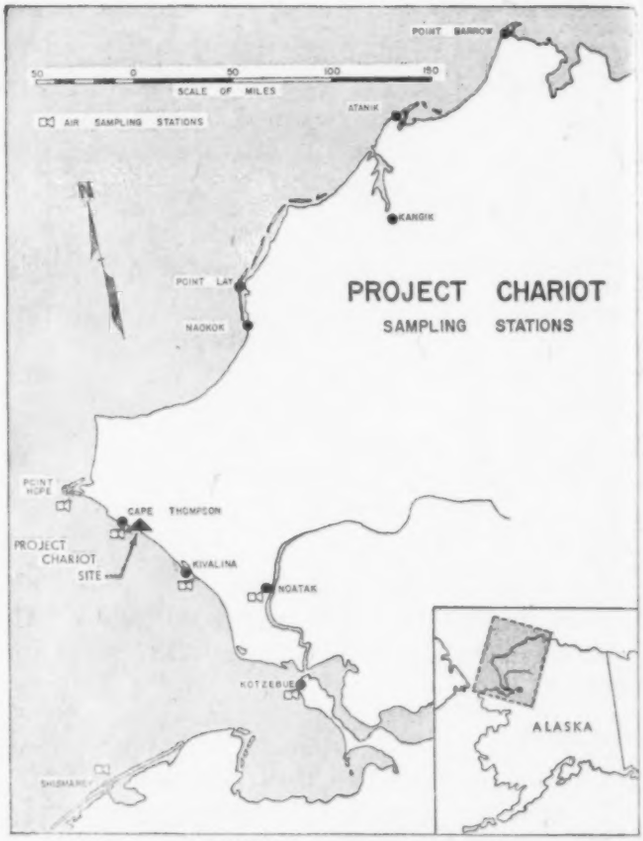

FIGURE 1.—PROJECT CHARIOT SAMPLING LOCATIONS

TABLE 1.—GROSS BETA ACTIVITY IN AIR NEAR THE PROJECT CHARIOT SITE, JANUARY–AUGUST 1962

[Average concentrations in $\mu\mu c/m^3$]

Location	Items	January	February	March	April	May	June	July	August
Cape Thompson	No. of samples	19	22	20	27	28	30	30	31
	Average beta	3.47	5.66	4.28	5.36	1.61	1.14	0.85	0.63
Kivalina	No. of samples	12	24	15	0	0	0	0	0
	Average beta	4.06	5.98	4.95					
Kotzebue	No. of samples	24	26	27	24	24	20	20	12
	Average beta	3.44	5.07	4.63	4.21	1.74	1.20	1.14	0.78
Noatak	No. of samples	0	0	0	11	7	0	14	13
	Average beta				2.27	1.49		0.73	1.09
Point Hope	No. of samples	21	28	30	21	25	30	29	23
	Average beta	4.36	6.08	4.68	4.01	1.77	1.15	0.77	0.74
Shishmaref	No. of samples	0	0	0	10	19	0	0	0
	Average beta				2.22	1.52			

Kotzebue and Point Hope, as shown in figure 1. During April 1962, two additional stations began operation. Monthly averages of gross beta activities in air for the period January–August 1962 are given in table 1.

Results of radiochemical analyses of water samples collected during September 1961 and May–August 1962 are presented in table 2. The samples are from drinking supplies unless otherwise indicated. No water samples were collected during the winter months October 1961 through April 1962.

TABLE 2.—RADIOCHEMICAL ANALYSIS OF WATER

[Concentrations in $\mu\mu c$/liter]

Location	Date of collection	Cs^{137}	Ba^{140}–La^{140}	Zr^{95}–Nb^{95}	Ru^{103}	I^{131}	Sr^{89}	Sr^{90}
Ogotoruk Creek	9/18/61	ND *	470	Trace			80	2
Kivalina	9/22/61	ND	240	ND			50	2
Kotzebue	9/23/61	ND	ND	ND			<5	<1
Cape Thompson (rain)	9/18–21/61	ND	1300	ND				
Point Hope	9/23/61	ND	ND	ND			<5	<1
Kivalina (snow)	5/1/62	ND	ND	ND	35	ND	95	9
Noatak	5/11/62	ND	ND	ND	ND	ND	50	<1
Point Hope	6/11/62	ND	ND	190	25		75	19
Noatak	6/11/62	ND	ND	45	65	ND	<5	1
Kotzebue	6/12/62	ND	ND	ND	ND	ND	<5	3
Kotzebue (rain)	6/12/62	ND	ND	80	35		45	28
Kivalina (rain)	6/25/62	ND	ND	165	30	ND	85	18
Shishmaref	6/30/62	ND	ND	70	ND	ND	55	10
Cape Thompson	7/2/62	ND	ND	ND	190	30	55	11
Cape Thompson	7/7/62	ND	ND	ND	ND	ND	<5	<1
Noatak (rain)	7/13/62	ND	ND	80	45	ND	35	7
Cape Thompson	7/17/62	<10	50	40		10	50	13
Shishmaref (rain)	7/20/62	<10	<20	<20		20		8
Kivalina	7/25/62	10	80	70		80	55	16
Point Hope	7/25/62	<10	<20	<20		10		6
Shishmaref	7/30/62	<10	<20	<20		20		
Cape Thompson	8/2/62	10	<20	40		<10	45	5
Noatak (rain)	8/20/62	65	40	300		<20	25	12
Point Hope (rain)	8/12/62	35	30	80		160	40	13
Kotzebue (rain)	8/26/62	15	<20	80		50	30	13

* ND indicates non-detectable.

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UNITS AND EQUIVALENTS

For the convenience of the *Radiological Health Data* (*RHD*) reader a selected list of units and equivalents is presented below.

Symbol	Name	Equivalent
Bev	billion electron volts	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	precipitation: $\text{mm} = \frac{\text{m}\mu\text{c/m}^3}{\mu\text{c/liter}} \times 1000 = \frac{\text{liter}}{\text{m}^3}$
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 $\mu\mu$c = 10^{-12} curies
r	roentgen	
$\mu\mu$c	micromicrocurie	1 $\mu\mu$c = 2.22 dpm

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